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ABSTRACT

This guide is intended to help teachers give preparatory instruction in the development of basic manipulative skills, safety practices, technical knowledge, and related industrial information in order to prepare students for useful employment in the field of electronics. This first-year guide contains 6 units organized in 21 lesson plans. Each lesson plan contains an aim; lists of teaching aids, materials, and references; prerequisites for students; a step-by-step presentation of the lesson (including teaching points, student activities, and things for the teacher to do or say); applications; evaluation; and a summary. Many lesson plans also include information sheets, assignment sheets, tests with answers, task sheets, activities with answer keys, and transparency masters. The following topics are covered in the lesson plans: orientation to electronics, safety, mathematics, components and symbols, meter measurements, hand and power tools, soldering, circuit construction, electricity, series resistive circuits, parallel resistive circuits, complex resistive circuits, D.C. meter circuits, magnetism, alternating current, inductance, and capacitance. A brief bibliography completes the teacher's guide. The student workbook, keyed to the teacher's guide, includes all or several of the following elements for each lesson: information sheets, assignment sheets, tests, task sheets, student activities, and puzzles. (KC)

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FIRST YEAR

TEACHER'S GUIDE FOR VOCATIONAL ELECTRONICS

Written by Chuck Solanik

Illustrated by Mike Harrison

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

INTRODUCTION

The purpose of this course is to give instruction of a preparatory type in the development of basic manipulative skills, safety practices, technical knowledge, and related industrial information in order to fit students for useful employment in the field of electronics. Vocational Electronics Course of Study is conveniently divided into first and second year, with a separate set of transparencies to accompany each. The Student Workbook for Vocational Electronics is also divided into first and second year. All of the above are available from Vocational Instructional Services. However, since the author, Mr. Chuck Solanik, felt it unnecessary to reinvent the wheel, he suggests using Introduction to Electricity and Electronics for lab experiments. This manual is listed in the bibliography.

OBJECTIVES

Upon successfully completing this two-year course of study the student will be able to:

1. Identify safe working practices and demonstrate skills in working safely.
2. Demonstrate proper techniques on the use, maintenance, and storage of tools and equipment used in electronics work.
3. Demonstrate understanding of direct current electronics related to current flow and voltage development related to resistance.
4. Demonstrate understanding of Ohm's Law and power.
5. Describe magnetism as it relates to inductance.
6. Design and build direct current circuits using breadboard and printed circuits.
7. Demonstrate understanding of alternating currents as related to measurements, wave forms, capacity and inductive circuits, and transformer and tuned circuits as used in radio and television.
8. Identify generators determining values of sinusoidal and nonsinusoidal waves.
9. Determine resistance in alternating current circuits.
10. Describe effects of resistors, capacitors, and inductors on alternating current.
11. Demonstrate and apply the characteristics of series parallel resonant circuits as found in radio and television.
12. Relate the frequency response of bend-pass, bend-stop, high-pass, and low-pass filters related to radio and television.
13. Demonstrate understanding of semi-conductors structure and operation.
14. Test semi-conductor diodes/transistors using volt-Ohm meters.
15. Describe zener diodes as they apply to voltage regulation.
16. Demonstrate the operation of transistors by observing and measuring their electrical characteristics.
17. Relate the basic theory of frequency modulation.

18. Apply frequency modulation as related to modulation percentage; side bend; radiated power; and modular systems including direct FM, indirect FM, reactance tube modulator, serrasoid modulator, and stereophonic multiplexing.

19. Demonstrate understanding of television systems and subsystems.

20. Demonstrate understanding of digital electronic circuits.

21. Demonstrate understanding of micro processor theory and logic.

22. Describe opportunities in the free enterprise system.

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I-A-1(I)

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Orientation
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate an understanding of: what electronics is, a brief history of electronics, areas of industry involving electronics, student's responsibilities to the course and school, and what he or she can expect to receive from the course.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, Figs. 1, 2
MATERIALS:	None
REFERENCES:	Information Sheets - Class Orientation, Grading System Grob, Bernard, Basic Electricity, 4th Ed., McGraw-Hill Inc., New York, 1977 Student Handbook, your high school The World Book Encyclopedia, Vol. 6, World Book International, Inc., Chicago, 1978
PREREQUISITE EXPERIENCE OF THE LEARNER:	None

I. PREPARATION (OF THE LEARNER - MOTIVATION)

What is electronics? Where is it used in industry? Where is it used in your everyday life? You plan to learn about electronics and use it to get a job in the electronics industry. Before doing this, you will learn in this lesson what electronics is and where it is used. This will help you understand all of the areas that you may go to work in.

You, as a student, will be in this course a large part of the school day for the next two years. What will you be doing during this time? What will you know when finished? How are you to act in class? How will grades be determined? These and many other questions that you have will be answered in this lesson.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Definition of Electronics	1. As a scientific study 2. Behavior of electrons 3. Electronic devices 4. Utilization of devices

B. History of Electronics

1. Greeks about 600 B. C.
   a. Rubbed amber rods with cloth
   b. Picked up straw and paper
   c. Known as static electricity
   d. Greek word for amber is "elektron"
2. William Gilbert
   a. Published paper in 1600
   b. Used modern terms "electric force" and "electric attraction"
   c. Called "father of electricity"
3. Benjamin Franklin
   a. Developed "condenser" to store static electricity
   b. 1752 - kite experiment
   c. Identified lightning with electricity
   d. Developed "fluid theory" of electricity
   e. Guessed wrong direction of flow but only recently proven
4. H. C. Oersted
   a. Danish physicist
   b. 1820 - showed magnetism and electric current relationship
5. Heinrich Hertz
   a. German physicist
   b. 1887 - demonstrated process of electromagnetic radiation through space
   c. Proved radio waves travel at speed of light waves
6. Guglielmo Marconi
   a. 1985 - developed practical radio system
   b. 1901 - produced wireless communications across Atlantic Ocean
7. Lee DeForest
   a. Leader in vacuum tube field
   b. 1906 - developed Audion Tube to amplify electric signals
8. Radio Station KDKA
   a. 1920 - in Pittsburg, Pennsylvania
   b. First AM station to broadcast regularly scheduled programs
9. FM radio and TV
   a. 1941 - Commercial FM broadcasting
   b. 1941 - Commercial TV broadcasting adopted
   c. Started after World War II

10. Transistors
    a. 1948 - invented by Bell Telephone
    b. In wide use by late 1950's
    c. Almost completely replaced vacuum tube

C. Related Career Fields

1. Business Equipment
    a. Manufacture, sales, service
    b. Calculators and computers
    c. Data processing equipment
2. Nucleonics
    a. Electronics related to atomic energy
    b. Safety, control, and test equipment
    c. Military and civilian equipment
3. Biomedical
    a. Manufacture, sales, operation, service
    b. Research equipment (Electron Microscope)
    c. Diagnostic equipment (Electrocardiograph)
    d. Treatment equipment (Diathermy)
4. Avionics
    a. Electronic systems for aircraft
    b. Military and civilian
5. Broadcasting
    a. AM and FM radio
    b. Television
6. Communications
    a. Two-way radio
    b. Telephone
7. Home entertainment
    a. Stereo equipment
    b. Tape systems
    c. Radio and TV receivers
    d. Electronic games

D. Course Subject Areas

1. First year
    a. Introduction
    b. Basic skills
    c. DC electricity
    d. DC resistive circuits
    e. Magnetism
    f. AC electricity
2. Second year
    a. Skill development
    b. AC circuits
    c. Semiconductors
    d. Electronic circuits
    e. Digital electronics
    f. Electronic systems

II. PRESENTATION (CONT')

E. Student Responsibilities

1. Participation
   - a. Come to class and be on time
   - b. Follow school rules
   - c. Practice safety
   - d. Study and prepare for class
   - e. Take care of equipment
   - f. Take active part in class, school, and V. I. C. A.

Show Transparency fig 1

2. Student duty assignments
   - a. Shop superintendent
   - b. Assistant superintendent
   - c. Safety supervisor
   - d. Tool room manager
   - e. Clean-up supervisor

F. Grading System

Show Transparency fig 2

1. Daily assignments - 60%
   - a. Written assignments
   - b. Lab experiments
   - c. Task assignments
   - d. Pop quiz
2. Tests - 40%
   - a. Unit tests
   - b. Major tests
   - c. Projects

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Have students take notes on lecture.
2. Have students read information sheets and place in their notebooks.
3. Stimulate discussion and answer student questions.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Ask oral questions

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHSIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Electronics is the field of science and engineering concerned with the behavior of electrons in devices and the utilization of such devices. Electricity is as old as the earth, but it took many years to unlock its secrets. Today electronic equipment can be found in all industries and plays a part in the daily lives of everyone.

You as a class have a lot to do in the next two years if you are to gain the skills and knowledge required to enter the field of electronics. It takes responsibility and hard work by a student to accomplish this goal. Do your part and you will be successful.

THE NEXT UNIT IS: Safety

STUDENT DUTY ASSIGNMENTS

Shop Superintendent

Assistant Superintendent

Safety Supervisor

Tool Room Manager

Clean-up Supervisor

SIX WEEKS GRADES

Daily Assignments = 60%

written assignments

lab experiments

task assignments

pop quiz

Test = 40%

tests

projects

I-A-1(IS)

INFORMATION SHEET
ON
ELECTRONICS CLASS ORIENTATION

SUBJECT: Course Content and Student Responsibility

INTRODUCTORY INFORMATION:

As students of electronics you should know what we will cover in this course. You should also know what will be expected of you and the system we will use to measure your progress.

GENERAL INFORMATION:

COURSE SUBJECT UNITS

I-A Orientation
-B Safety
-C Mathematics
-D Leadership
II-A Components
-B Measurements
-C Tools
-D Soldering
-E Circuit Construction
III-A Technical Skills
-B Life Skills
IV-A Basic Electricity
-B Resistance
-C Ohm's Law and Power
V-A Series Circuits
-B Parallel Circuits
-C Combination Circuits
VI-A Magnetism
-B Electromagentic Devices
VII-A Alternating Current
-B Inductance
-C Capacitance
VIII-A AC Mathematics
-B R-L-C Circuits
IX-A Semiconductors
-B Diodes
-C Transistors
-D Special Devices
X-A Power Supplies
-B Amplifiers
-C Oscillators
-D Other Circuits
XI-A Digital Intro
-B Logic Gates
-C Flip-Flops
-D Counters and Registers
-E Digital Circuits
XII-A Radio and TV Systems
-B Communications
-C Instrumentation
-D Computers
-E Other Systems

SIX WEEKS GRADES

60% Daily Assignments	40% Tests
- Written assignment	- Unit exams
- Task assignment	- Completed projects
- Lab experiment	
- Pop quiz	

ABSENCES

Absences should be kept to a minimum. It is your responsibility to come to class and make up all missed work if you are absent. Most work can and should be made up before returning to class. Contact your lab partner for assignments and/or hand out sheets. A pop quiz cannot be made up; however, the lowest daily grade each six weeks will be dropped.

TARDIES

It is your responsibility to be in your seat and ready to begin when the tardy bell rings. There will be no excused tardies. You will be warned on your 1st and 2nd tardy. On your 3rd, you will lose your breaks for 10 days. On each subsequent tardy, you will lose breaks for an additional 10 days and be sent to the Vice Principal's office.

BREAKS

The time between class periods can be used as a break if you wish. It is a good time to stretch, get a drink of water or use the rest room. It is not considered time to stand in the main doorway or to horseplay. The taking of breaks is a privilege which can be lost if there are problems.

STUDENT DUTY ASSIGNMENTS

SHOP SUPERINTENDENT

1. Supervises other officers and class members.
2. Greets visitors and offers them safety glasses.
3. Answers the telephone when necessary.
4. Relays reports from the other officers to the instructor.

ASSISTANT SUPERINTENDENT

1. Replaces other officers when they are absent.
2. Assists the tool room manager.

SAFETY SUPERVISOR

1. Checks for unsafe work practices.
2. Checks shop for safety hazards.
3. Greets visitors and offers them safety glasses.
4. Checks equipment to be sure power is off at the end of class.
5. Makes daily report to the shop supervisor and instructor on safety.

TOOL ROOM MANAGER

1. Issues and receives tools and equipment.
2. Improves the tool room.
3. Inventories all tools and equipment at the end of each class.
4. Makes daily report to the shop supervisor on missing or damaged tools.

CLEAN-UP SUPERVISOR

1. Calls for class clean-up.
2. Supervises students in clean-up assignments.
3. Makes daily report to the shop supervisor when all clean-up work is complete.

I-A-1a(IS)

INFORMATION SHEET
ON
GRADING SYSTEM

SUBJECT: Grading System

INTRODUCTORY INFORMATION:

Earlier we spoke of the system we will use to measure your progress. This, of course, means grades, and the following is the method we will use.

GENERAL INFORMATION:

Name ______________________ Semester __________ 6 Wks ____ Avg ____

DATE:	DAILY ASSIGNMENTS:	GRADE:
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

TESTS:	GRADE:
1	
2	
3	
4	
5	
6	

TO CALCULATE SIX WEEKS GRADE AVERAGE

1. Calculate daily average = ________
2. Calculate test average = ________
3. Multiply daily average by 0.6 = ________
4. Multiply test average by 0.4 = ________
5. Add results of line 3 and line 4 together = ________
6. Round off and enter at the top of this sheet.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

I-B-1(I)

SUBJECT: Safety

AIMS: Upon successful completion of the lesson, the student will have sufficient safety knowledge to perform safely in the school electronics shop and around electrical equipment.

TEACHING AIDS: Chalkboard, Transparencies 19500, figs. 3-6 overhead projector

MATERIALS:
Information Sheet - Electrical Safety (teacher prepared)
Information Sheet - General Safety Rules
Information Sheet - Accident Report Form

Assignment Sheet - Safety
Experiment #1 - Safety, Power Sources and Metering
Test Sheet - Safety
Parent Permission Form

TOOLS AND EQUIPMENT: Student lab station, component set

REFERENCES:
Information Sheets
Fowler, Electricity - Theory and Applications
Woodburn, Safety for the Industrial Student
You and Your Eyes, Channing Bete Co., Greenfield, MA, 1974
De Vito, Introduction to Electricity and Electronics, Laboratory Experiments Manual

PREREQUISITE EXPERIENCE OF THE LEARNER: None

I. PREPARATION (OF THE LEARNER - MOTIVATION)

The ability to work safely is the most important habit anyone can have. Without this habit no employee will keep a job very long, and no student can remain in this shop. Working safely involves at least three different things: your safety, the safety of those around you, and the safety of tools, equipment, and property. The most important safety rule is to know what you are doing, think before you act, and then use good common sense. It is impossible to think of a single safety rule that would cover every possible occasion. Therefore, it is very important that you always know what you are doing and work with your safety, as well as the safety of everyone around you, in mind.

II. PRESENTATION (OF THE INFORMATION)

	INSTRUCTIONAL TOPICS TEACHING TOPICS		THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A.	Need for Safety Show Transparency fig. 3	1.	Definitions
			a. Safety: safeness, protection, or safekeeping
			b. Safe: free from danger or injury; secure
		2.	Self protection: protect yourself from injury or death
		3.	Protect others around you
			a. Their well being depends partly on you
			b. It takes teamwork
		4.	Protect equipment
			a. Equipment costs money
			b. Hard to replace
B.	Types of Safety	1.	Non-electrical: behavior to prevent accidents other than electrical
		2.	Electrical: protection from damage electricity can do
C.	Electrical Shock Show Transparency fig. 4	1.	Amount of current
		2.	Path through body
		3.	Duration of time
D.	Safety Rules Show Transparency fig. 5	1.	No horseplay
		2.	Check equipment for defects
		3.	Wear eye protection when needed
		4.	Stay dry and well insulated
		5.	Careful with hot soldering irons
		6.	Don't touch if you don't understand
		7.	Never lift heavy objects alone
		8.	Avoid inhaling vapors
		9.	Never defeat safety devices
		10.	Think before doing
E.	Emergency Procedures Show Transparency fig. 6	1.	Get person off current source
		2.	Call for help
		3.	First aid
		4.	Building evacuation
		5.	Accident reports
F.	Fire Extinguishers	1.	Locations in shop
		2.	Types of fires
		3.	Types of extinguishers
		4.	Operation

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Information Sheet - Electrical Safety.
2. Assignment Sheet - Shop Safety.
3. Experiment Sheet #1 (Demonstration).
4. Have students write a one-page essay titled: "Why Safety is for Me!".
5. Have students make a safety poster on 8½ x 11 inch poster board. Poster should emphasize a safety rule or some phase of shop safety.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions.
2. Test Sheet - Shop Safety.
3. 100% correct required for satisfactory completion of the lesson.
4. Each student is to complete the Student's Safety Statement and have their parents complete the Parent Permisssion Form.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

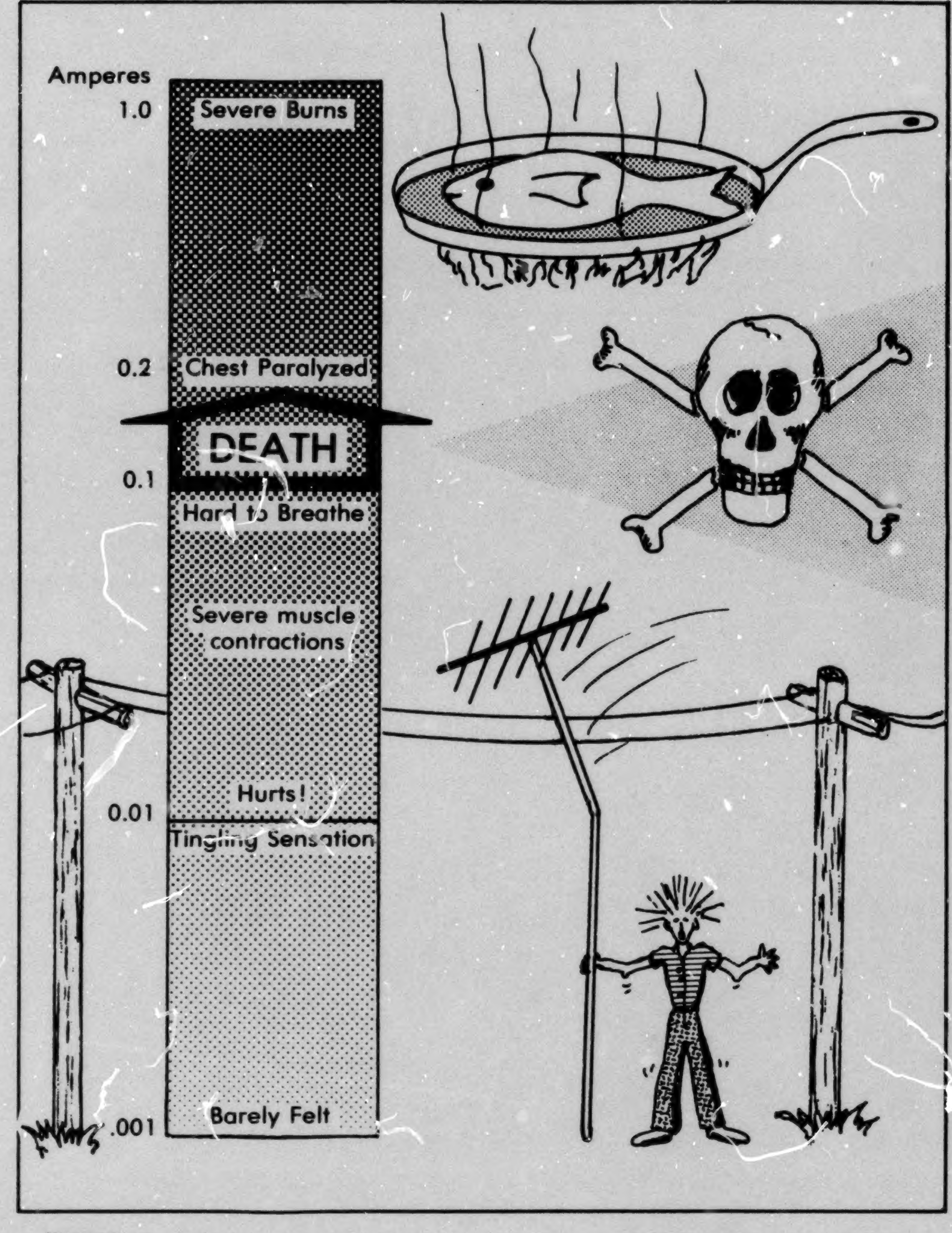
1. Discuss test and answer student questions.
2. Review major topics of presentation.
3. Review shop safety rules.

THE NEXT UNIT IS: Mathematics

1976
in
SAN ANTONIO

Electrical Fires	691
Electrical Fire Deaths	2
Electrocutions	24
Fire Deaths	20

Fig. 3


Amperes
1.0
Severe Burns
0.2
Chest Paralyzed
DEATH
0.1
Hard to Breathe
Severe muscle contractions
Hurts!
0.01
Tingling Sensation
Barely Felt
.001

VOCATIONAL ELECTRONICS
SAFETY RULES

1. No horseplay
2. Check equipment for defects
3. Always wear eye protection when needed
4. Stay dry and well insulated
5. Be careful - soldering irons are hot
6. Don't touch if you don't understand
7. Never lift heavy objects alone
8. Avoid inhaling vapors
9. Never defeat safety devices
10. Think before doing!

HOW SERIOUS AN ELECTRICAL ACCIDENT IS DEPENDS ON:

1. How much current passes through the body.
2. Path of the current through the body.
3. Length of time current passes through the body.

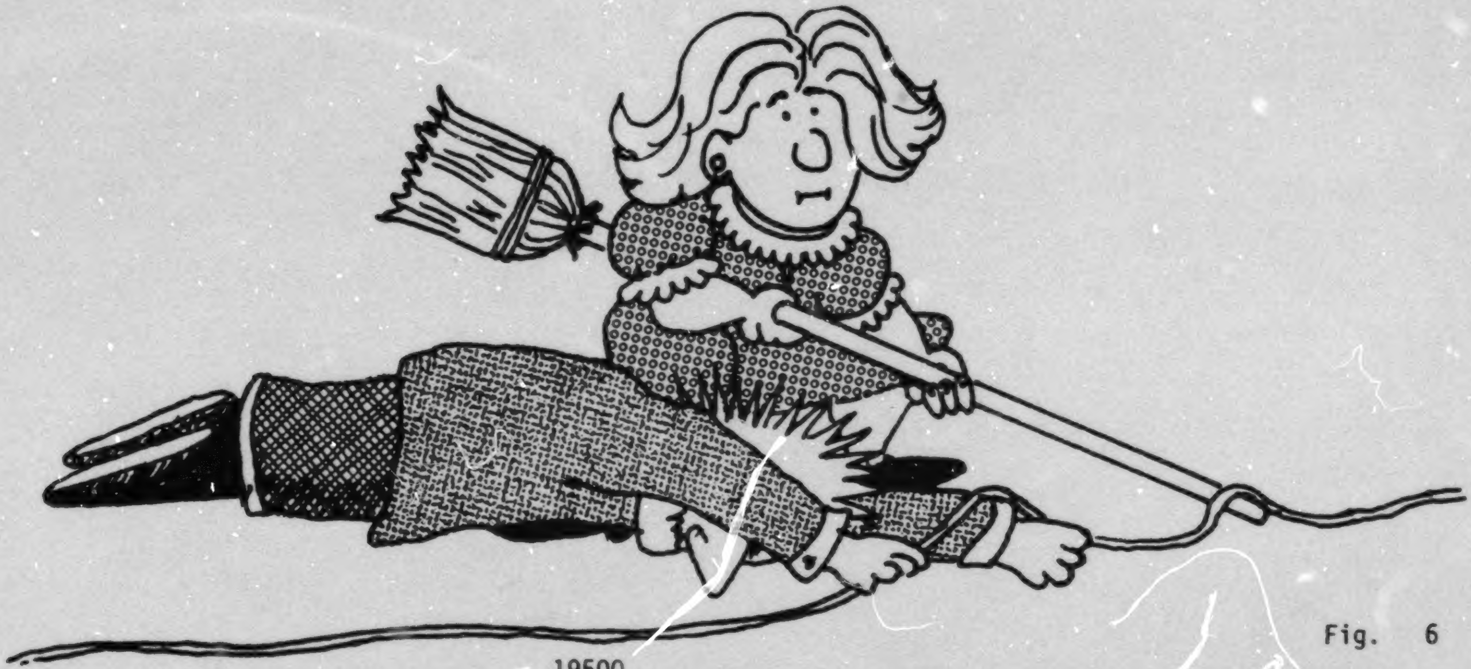


Fig. 6

INFORMATION SHEET
ON
SAFETY RULES

1. NO HORSEPLAY --

   It may begin in fun and end in tragedy!

2. CHECK ALL TOOLS AND EQUIPMENT FOR DEFECTS BEFORE USING ---

   Report anything you feel may be defective to the instructor.

3. DON'T TOUCH ANYTHING YOU DON'T UNDERSTAND ---

   Ask if you are not sure!

4. STAY DRY AND WELL INSULATED ---

   Increase your chances of not receiving an electrical shock!

5. SOLDERING IRONS ARE HOT --BE CAREFUL ---

   They will burn you and your clothes, care must be taken!

6. ALWAYS WEAR EYE PROTECTION WHEN NEEDED ---

   Eye protection is required when soldering, unsoldering, sawing, cutting or drilling any material and when handling any chemicals. Molten solder, metal particles and chemicals in the eye can cause blindness.

7. NEVER LIFT HEAVY OBJECTS ALONE ---

   When you lift a heavy object, keep your body straight and push the body upward with the legs. Get Help!

8. AVOID INHALING VAPORS AND SMOKE ---

   It can cause lung damage or death!

9. NEVER DEFEAT SAFETY DEVICES ---

   They are there to protect you!

10. THINK BEFORE DOING!

ACCIDENT REPORT FORM

Name ______________________________ Date ________________________

DIRECTIONS: A report must be made on all accidents. Answer all of the questions completely and accurately. If more space is needed, use the other side of this sheet.

1. Were you involved in the accident or a witness to it?

2. Were there any injuries? If yes, describe them as best you can.

3. Do you feel a safety rule was violated? If yes, which one?

4. Do you feel a new safety rule is needed to prevent another accident of this type?

5. How could the accident have been avoided?

6. Describe what happened in your own words. Be complete, name names, etc.

ASSIGNMENT SHEET
ON
SHOP SAFETY

Name ______________________ Date ______________

Directions: Each student is to complete this assignment sheet on an individual basis. Read each question carefully before answering. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

List the ten general safety rules which are to be followed in this shop and explain why you feel each is necessary.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

List the three primary factors in determining the severity of an electrical shock.

1. ______________________
2. ______________________
3. ______________________

List three damaging effects other than electrical shock that electricity can have.

1. ______________________
2. ______________________
3. ______________________

Write a brief statement on why it is necessary for every person in this shop are to think safety at all times.

____

____

____

____

__________________ SCHOOL DISTRICT

PARENT PREMISSION FORM

_____ - _____ SCHOOL YEAR

This is to certify that my son/daughter, ______________________________, has my full permission to participate in all areas of the Vocational Electronics program at ____________________ High School under the supervision of the instructor, Mr./Ms. ____________________.

I hereby release the _________________________ Independent School District, the school administration, and the instructor involved from any liability for injuries and fatalities suffered by my child while participating in the Vocational Electronics program at ______________________________ High School.

___________________________________ ______________________________

Signature of Parent or Guardian   Date

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STUDENT'S SAFETY STATEMENT FORM

I have received a copy of the shop safety rules for study and insertion in my notebook. I have read and studied the specific safety rules posted on equipment and in the shop.

I fully understand all the safety rules which apply to this shop. I now feel that I am conversant with sufficient safety instruction to warrant my using shop equipment. My knowledge of shop safety is reasonably indicated by the percentage grade on my safety test.

I hereby promise most sincerely to observe all safety rules set up in this shop. Furthermore, I will try to protect others from hazards and accidents and if necessary call the attention of the instructor to any violation of the safety rules.

___________________________________ ______________________________

Signature of the Student   Date

___________________________________ ______________________________

Signature of the Instructor   Safety Test Grade

SAFETY TEST

Name ______________________ Date ____________________

DIRECTIONS: List the ten general safety rules that must be followed in this shop at all times.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

DIRECTIONS: List the three primary factors that determine how severe an electrical shock will be.

11. ____________________
12. ____________________
13. ____________________

DIRECTIONS: Write a brief statement explaining why you feel the shop safety rules must be followed by every person in this shop.

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INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT: Mathematics

AIMS: Upon successful completion of the lesson, the student will be able to apply scientific notation, metric prefixes, and the use of a calculator to solve mathematical problems related to the field of electronics.

TEACHING AIDS: Chalkboard, overhead projector, Transparencies 19500, fig. 7

MATERIALS:
Information Sheet - Scientific Notation and Metric Prefixes
Assignment Sheet - Mathematics Review
Assignment Sheet - Scientific Notation
Assignment Sheet - Metric Prefixes
Test Sheet - Mathematics

TOOLS AND EQUIPMENT: Calculator

REFERENCES: Andrews, Alan, Electronics Math, Howard Sams Co., Indianapolis, 1975

PREREQUISITE EXPERIENCE OF THE LEARNER: Algebra prerequisite only

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I. PREPARATION (OF THE LEARNER - MOTIVATION)

The technical field of electronics is based on mathematical relationships that exist between various electrical properties found in electronics circuits. An understanding of these properties is made possible through the use of mathematics. The most often used mathematics processes include arithmetic, algebra, and trigonometry. Probably the most important single subject involves substituting into and manipulating the various electronics formulas. In this lesson you will review your arithmetic and algebra. You will also learn to solve electronics problems using scientific notation and a calculator. Also included will be metric prefixes, a simpler form of writing answers, and naming component values.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Arithmetic Review	1. Addition a. Demonstrate process b. Show example problems 2. Subtraction a. Demonstrate process b. Show example problems

3. Multiplication
    a. Demonstrate process
    b. Show example problems
4. Division
    a. Demonstrate process
    b. Show example problems
5. Fractions
    a. Demonstrate process
    b. Show example problems
6. Percentages
    a. Demonstrate process
    b. Show example problems
7. Reciprocals
    a. Demonstrate process
    b. Show example problems
8. Rounding-off
    a. Demonstrate process
    b. Show example problems

B. Algebra Review

1. Substitution into formula
    a. Demonstrate process
    b. Show example problems
2. Solving equations
    a. Demonstrate process
    b. Show example problems

C. Scientific Notation
Show Transparency fig. 7

1. Conversion of whole numbers
    a. Demonstrate process
    b. Examples:
        (1) $6,000 = 6 \times 10^{3}$
        (2) $750,000 = 75 \times 10^{4}$
2. Conversion of decimal numbers
    a. Demonstrate process
    b. Examples:
        (1) $0.0003 = 3 \times 10^{-4}$
        (2) $0.075 = 7.5 \times 10^{-2}$
3. Addition
    a. Demonstrate process
    b. Stress: All numbers must be converted to "times ten" to the same power
    c. Examples:
        (1) $(3 \times 10^{6}) + (7 \times 10^{6}) = 10 \times 10^{6}$
        (2) $(3.5 \times 10^{3}) + (6.5 \times 10^{3}) = 10 \times 10^{3}$
4. Subtraction
    a. Demonstrate process
    b. Stress: All numbers must be converted to "times ten" to the same power

c. Examples:
  (1) $(3 \times 10^4) - (2 \times 10^4) = 1 \times 10^4$
  (2) $(6 \times 10^{-6}) - (4 \times 10^{-6}) = 2 \times 10^{-6}$

5. Multiplication
  a. Demonstrate process
  b. Stress: The coefficients are multiplied but the exponents of ten are added
  c. Examples:
    (1) $(3 \times 10^3) \times (3 \times 10^4) = 9 \times 10^7$
    (2) $(8 \times 10^{-3}) \times (2 \times 10^2) = 16 \times 10^{-1}$
    (3) $(3 \times 10^{-3}) \times (2 \times 10^6) = 6\ 10^3$
    (4) $(4 \times 10^{-3}) \times (6 \times 10^{-2}) = 60 \times 10^{-6}$

6. Division
  a. Demonstrate process
  b. Stress: The coefficients are divided but the exponents of ten are subtracted (top minus bottom)
  c. Examples:
    (1) $(3 \times 10^3) \div (3 \times 10^4) = 1 \times 10^{-1}$
    (2) $(8 \times 10^{-3}) \div (2 \times 10^2) = 4 \times 10^{-5}$
    (3) $(3 \times 10^{-3}) \div (2 \times 10^6) = 1.5 \times 10^{-9}$

7. Square roots
  a. Process
    (1) Write number so the exponent of ten is an even number
    (2) Take the square root of the coefficient using a calculator or table
    (3) Divide the exponent by two
  b. Examples:
    (1) $\sqrt{9 \times 10^4} = 3 \times 10^2$
    (2) $\sqrt{9 \times 10^5} = 0.949 \times 10^3$
    (3) $\sqrt{80 \times 10^7} = \sqrt{8 \times 10^8} = 2.83 \times 10^4$

8. Reciprocals
  a. Demonstrate process
    (1) Take reciprocal of number (divide 1 by the number)
    (2) Change the sign of the exponent of the power of ten
  b. Show example problems

D. Metric Prefixes

1. Define
2. Example of use
  a. Large units of measure: resistance, voltage, frequency and power
  b. Small units of measure: voltage, current and capacitance

3. Common metric prefixes and conversion
   a. Tera (T) 12 decimal places to the left
   b. Giga (G) 9 decimal places to the left
   c. Mega (M) 6 decimal places to the left
   d. Kilo (K) 3 decimal places to the left
   e. milli (m) 3 decimal places to the right
   f. micro (μ) 6 decimal places to the right
   g. nano (n) 9 decimal places to the right
   h. pico (p) 12 decimal places to the right
4. Conversions back to basic units
   a. Process steps
      (1) Remove metric prefix letter
      (2) Add the number of zeros that had to be deleted from the unit
      (3) Move the decimal back to the original position as indicated by the prefix
   b. Show example problems

E. Calculators

1. Student supplied
2. Individual instruction from specific instruction book

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Mathematics Review
2. Assignment Sheet - Scientific Notation
3. Assignment Sheet - Metric Prefixes
4. Check each student's work for completeness and accuracy.
5. Answer any student questions.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions.
2. Test Sheet - Mathematics.
3. 70% correct is required for satisfactory completion of the lesson.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer any student questions.
2. Review major topic of presentation.

THE NEXT LESSON IS: Leadership

SCIENTIFIC NOTATION		METRIC PREFIXES	
1,000,000,000,000	X 10^{12}	TERA	T
1,000,000,000	X 10^{9}	GIGA	G
1,000,000	X 10^{6}	MEGA	M
1,000	X 10^{3}	KILO	K
1	X 10^{0}	UNIT	
.001	X 10^{-3}	MILLI	m
.000 001	X 10^{-6}	MICRO	μ
.000 000 001	X 10^{-9}	NANO	n
.000 000 000 001	X 10^{-12}	PICO	p

Fig. 7

SCIENTIFIC NOTATION		METRIC PREFIXES	
1,000,000,000,000	X 10^{12}	TERA	T
1,000,000,000	X 10^{9}	GIGA	G
1,000,000	X 10^{6}	MEGA	M
1,000	X 10^{3}	KILO	K
1	X 10^{0}	UNIT	
.001	X 10^{-3}	MILLI	m
.000 001	X 10^{-6}	MICRO	μ
.000 000 001	X 10^{-9}	NANO	n
.000 000 000 001	X 10^{-12}	PICO	p

MATHEMATICS REVIEW

I-C-1a(AS)
Key

Name ______________________________ Date ____________________

A. DIRECTIONS: Perform the following operations without the use of a calculator. Show all work on a work sheet. Write your final answers in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

ADD:	SUBTRACT:	MULTIPLY:	MULTIPLY:	DIVIDE:
1. 10,532	2. 70,605	3. 78	4. 6,924	5.
49	61,926	54	462	7006.72043
617	8,679	4,212	3,198,888	$93\,\overline{)651{,}625}$
8,052				
98,135				
117,385				

B. DIRECTIONS: Round off the following numbers to the three significant figures. Be sure to check your answers and write them in the spaces provided. If you have any questions, ask your instructor.

1.	7,206	7,210	16.	7006.7204	7,010	31.	0.30285	0.303
2.	6,444	6,440	17.	42.17647	42.2	32.	2,512	2,510
3.	98,356	98,400	18.	57.45	57.5	33.	0.9425	0.943
4.	29,755	29,800	19.	0.1388	0.139	34.	573.5988	574
5.	126,387	126,000	20.	22.891663	22.9	35.	188.496	188
6.	4,533,522	4,530,000	21.	19.52136	19.5	36.	0.0045126	0.00451
7.	28,936	28,900	22.	796.8287	797	37.	189.999	190
8.	44,363	44,400	23.	2.8	2.80	38.	17.0067	17.0
9.	8,679	8,680	24.	0.99328	0.993	39.	210.561	211
10.	2,860	2,860	25.	0.199328	0.199	40.	3.14159	3.14
11.	21	21.0	26.	1.5974	1.60	41.	0.00055	0.000550
12.	211	211	27.	1.7203	1.72	42.	2.478	2.48
13.	4906.2222	4,910	28.	32.6005	32.6	43.	68.4	68.4
14.	892.56521	893	29.	27.7982	27.8	44.	4.7	4.70
15.	293.94736	294	30.	36.4554	36.5	45.	0.0009602	0.000960

C. DIRECTIONS: Perform the following operations. You may use a calculator if you have one. Round off your answers to three significant figures and write them in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

1. 208 + 43 + 6,955 = 7,210
2. 71 + 979 + 856 = 1,910
3. 3,594 + 2,216 + 634 = 6,440
4. 8,015 + 32 + 500 + 4 = 8,550
5. 87,645 + 923 + 9,769 = 98,300
6. 4,379 + 5,083 + 9,752 = 19,200
7. 67,841 + 80,936 + 245 = 149,000
8. 264 + 58,198 + 4,589 = 63,100
9. 46 - 25 = 21.0
10. 94 - 32 = 62.0
11. 725 - 687 - 25 - 2 = 11.0
12. 950 - 63 - 84 = 803
13. 58,761 - 14,398 = 44,400
14. 70,605 - 61,679 - 210 = 8,720
15. 8,432 - 853 - 2,134 = 5,450
16. 82,570 - 52,491 - 999 = 29,100
17. 493 x 7 = 3,450
18. 8,210 x 9 = 73,900
19. 154 x 82 = 12,600
20. 209 x 17 x 63 = 224,000
21. 853 x 63 x 54 = 2,900,000
22. 7,613 x 54 x 10 = 4,110,000
23. 6,975 x 493 x 3 = 10,300,000
24. 96 x 7 x 493 x 3 = 994,000
25. 322 / 7 = 46.0
26. 44,156 / 9 = 4,910
27. 20,529 / 23 = 893
28. 717 / 24 = 29.9
29. 75 / 33 = 2.27
30. 61,051 / 3,007 = 20.3
31. 651,615 / 19 = 34,300
32. 7,035 / 48 = 147
33. 24.6 + 32.85 = 57.5
34. 168.5 + 0.123 = 169
35. 0.0002 + 0.1368 = 0.139
36. 0.002 + 7.46 + 123 = 130
37. 12.6 - 9.8 = 2.80
38. 93.25 - 6.42 = 86.8
39. 108.4362 + 99.5862 = 208
40. 0.00068 - 0.00032 = 0.000360
41. 163 x 0.2 = 32.6
42. 176 x 0.25 = 44.0
43. 0.678 x 41 = 27.8
44. 3.87 x 9.42 = 36.5
45. 67.3 x 0.0045 = 0.303
46. 0.00275 / 5 = 0.000550
47. 17½ % of 350 = 61.3
48. 1 % of 1,975 = 19.8
49. 80 % of 56 = 44.8
50. 45 % of 26 = 11.7

SCIENTIFIC NOTATION

I-C-1b(AS)
Key

Name ______________________________ Date ____________________

DIRECTIONS: Perform the following operations and round off your answers to three significant figures. Answers that are to be written in scientific notation should be written as a number between 1 and 10 times ten to a power. Example: 3.45×10^{3}. Write your answers in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

A. Convert to Scientific Notation:

1. 142.53 = 1.43×10^{2}
2. 150,000 = 1.50×10^{5}
3. 0.00336 = 3.36×10^{-3}
4. 4,663,310.56 = 4.66×10^{6}
5. 86,400 = 8.64×10^{4}
6. 0.12500 = 1.25×10^{-1}
7. 0.00125 = 1.25×10^{-3}
8. 0.000000000000144 = 1.44×10^{-13}
9. 65,500,000,000,000 = 6.55×10^{13}
10. 0.000006835 = 6.84×10^{-6}

B. Convert to Standard Notation:

11. 1.63×10^{7} = 16,300,000
12. 4.781354×10^{3} = 4,780
13. 1.01×10^{6} = 1,010,000
14. 9.81×10^{1} = 98.1
15. 3.1145×10^{-4} = 0.000311
16. 6.5545×10^{12} = 6,550,000,000,000
17. 8.001×10^{-5} = 0.0000800
18. 9.34512×10^{-6} = 0.00000935
19. 6.28×10^{6} = 6,280,000
20. 3.1415926×10^{0} = 3.14

C. Solve the Following:

21. $(1.60 \times 10^{2}) + (3.20 \times 10^{2})$ = 4.80×10^{2}
22. $(1.50 \times 10^{2}) + (1.50 \times 10^{3})$ = 1.65×10^{3}
23. $(3.20 \times 10^{3}) + (2.00 \times 10^{2})$ = 3.40×10^{3}
24. $(3.40 \times 10^{-3}) + (1.60 \times 10^{-4})$ = 3.56×10^{-3}
25. $(3.20 \times 10^{2}) - (1.60 \times 10^{2})$ = 1.60×10^{2}
26. $(1.50 \times 10^{3}) - (1.50 \times 10^{2})$ = 1.35×10^{3}
27. $(3.20 \times 10^{3}) - (2.00 \times 10^{2})$ = 3.00×10^{3}
28. $(3.40 \times 10^{-3}) - (1.60 \times 10^{-4})$ = 3.24×10^{-3}
29. $(1.50 \times 10^{2}) \times (1.50 \times 10^{-2})$ = 2.25×10^{0}
30. $(3.20 \times 10^{6}) \times (5.20 \times 10^{-3})$ = 1.66×10^{4}

31. $(1.60 \times 10^{0}) \times (4.80 \times 10^{1}) =$ 7.68×10^{1}

32. $(9.30 \times 10^{-6}) \times (2.80 \times 10^{3}) =$ 2.60×10^{-2}

33. $(0.000256) / (0.000000338) =$ 7.57×10^{2}

34. $(0.000000857) / (856{,}000{,}000) =$ 1.000×10^{-15}

35. $(156{,}000 \times 10^{4}) / (67.6 \times 10^{-3}) =$ 2.31×10^{10}

36. $(5.36 \times 10^{-5}) / (0.0000845) =$ 6.34×10^{-1}

37. $\sqrt{16.0 \times 10^{5}} =$ 1.26×10^{3}

38. $\sqrt{756 \times 10^{7}} =$ 8.69×10^{4}

39. $\sqrt{23.0 \times 10^{9}} =$ 1.52×10^{5}

40. $\sqrt{23.5 \times 10^{13}} =$ 1.53×10^{7}

41. $\dfrac{4{,}914{,}000}{0.0078 \times 63{,}000} =$ 1.00×10^{4}

42. $\dfrac{0.000256 \times 0.000000338}{865{,}000{,}000} =$ 1.00×10^{-19}

43. $\dfrac{156{,}000 \times 10^{4} \times 248 \times 10^{6}}{67.0 \times 10^{-3}} =$ 5.77×10^{18}

44. $\dfrac{704 \times 10^{-6} \times 485{,}000 \times 10^{3}}{573 \times 10^{-8} \times 6.28 \times 10^{12}} =$ 9.49×10^{-3}

45. $\dfrac{1 \times 10^{0}}{6.28 \times 60 \times 25 \times 10^{-6}} =$ 1.06×10^{2}

46. $\dfrac{0.0022 \times 600}{3.00 \times 10^{-10}} =$ 4.40×10^{9}

47. $\dfrac{5.00 \times 10^{-5} \times 2400}{0.00008 \times 3.00 \times 10^{10}} =$ 5.00×10^{-8}

48. $\dfrac{6.02 \times 10^{23} \times 1.60 \times 10^{-19}}{16.0 \times 10^{-2}} =$ 6.02×10^{5}

49. $\dfrac{0.000004532 \times 10^{6} \times 16{,}502 \times 10^{3}}{1{,}532 \times 10^{3} \times 8{,}415 \times 10^{-6}} =$ 5.80×10^{3}

50. $\dfrac{653{,}200 \times 10^{-1} \times 8.413 \times 10^{0}}{48.0 \times 10^{2} \times 0.003 \times 10^{1}} =$ 3.81×10^{6}

METRIC PREFIXES

I-C-1c(AS)
Key

Name ____________________ Date ____________________

DIRECTIONS: Make the following conversions and write the answers in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

0.0000271 H	1.	Change 27.1 microhenrys to Henrys. (Inductance)
2,710 μ H	2.	Change 0.00271 Henrys to microhenrys. (Inductance)
0.950 KHz	3.	Change 950 Hertz to kilohertz. (A. C. Frequency)
0.00000000015 F	4.	Change 0.00015 microfarad to Farads. (Capacitance)
2.70 pF	5.	Change 2.7 x 10^{-12} Farads to picofarads. (Capacitance)
4,600,000 Ω	6.	Change 4.6 megohms to Ohms. (Resistance)
.0335 V	7.	Change 33.5 millivolts to Volts. (Voltage)
2.265 W	8.	Change 2,265 milliwatts to Watts. (Power)
45.8 μ V	9.	Change 4.58 x 10^{-5} Volts to microvolts. (Voltage)
35 μ H	10.	Change 0.035 millihenrys to microhenrys. (Inductance)
0.00315 mV	11.	Change 3.15 microvolts to millivolts. (Voltage)
0.000100 μ F	12.	Change 100 picofarads to microfarads. (Capacitance)
2,460 K Hz	13.	Change 2.46 megahertz to kilohertz. (A.C. Frequency)
5,000,000 mV	14.	Change 5 kilovolts to millivolts. (Voltage)
19,000,000 pF	15.	Change 19 microfarads to picofarads. (Capacitance)
1 μ Sec	16.	Change 0.000001 Seconds to microseconds. (Time)
3.23 KW	17.	Change 3,230 Watts to kilowatts. (Power)
50 M Ω	18.	Change 5 x 10^{7} Ohms to megohms. (Resistance)
1,450 KΩ	19.	Change 1.45 megohms to kilohms. (Resistance)
.56 m Sec	20.	Change 0.00056 Seconds to milliseconds. (Time)
1,020 Hz	21.	Change 1.02 kilohertz to Hertz. (A. C. Frequency)
18 p Sec	22.	Change 0.018 nanoseconds to picoseconds. (Time)
98 mA	23.	Change 0.098 Amperes to milliamperes. (Current)
68.4 μ A	24.	Change 0.0684 milliampere to microampere. (Current)
100 pF	25.	Change 0.0001 microfarad to picofarad. (Capacitance)
3.5 KΩ	26.	Change 3,500 Ohms to kilohms. (Resistance)

DIRECTIONS: Complete the following chart.

UNITS	SCIENTIFIC NOTATION	METRIC PREFIXES
0.25 Ampere	27. 2.50×10^{-1} A	28. 250 ma
29. 3,000,000 Ω	3.00×10^{6} Ohms	30. 3 MΩ
31. 0.000,000,000,005F	32. 5.00×10^{-12} F	5 p Farad
5,000 Volts	33. 5.00×10^{3} V	34. 5 KV
35. 0.00170 H	1.70×10^{-3} Henry	36. 1.70 mH
37. 0.000006 W	38. 6.00×10^{-6} W	6 μ Farad
7,000,000,000 Hertz	39. 7.00×10^{9} Hz	40. 7 G Hz
41. 0.000,000,002 Sec	2.00×10^{-9} Second	42. 2 n Sec
43. 47,000 V	44. 4.70×10^{4} V	47 K Volts
0.0001 Ampere	45. 1.00×10^{-4} A	46. 100 μ A
47. 1,000 Ω	1.00×10^{3} Ohms	48. 1 KΩ
49. 150,000 000 Hz	50. 1.50×10^{8} Hz	150 M Hertz

MATHEMATICS TEST

I-C-1(T)
Key

NAME ______________________________ DATE ____________________

DIRECTIONS: Perform the following operations using scientific notation. Round off your answers to three significant figures. Write your answers in the spaces provided as a number between 1 and 10 times ten to a power. Be sure to check your answers. You may use a calculator if you have one.

4.19×10^{3} 1. $(1.65 \times 10^{3}) + (2.54 \times 10^{3}) =$

3.71×10^{3} 2. $(3.24 \times 10^{3}) + (4.65 \times 10^{2}) =$

3.73×10^{-1} 3. $(3.78 \times 10^{-1}) - (4.56 \times 10^{-3}) =$

1.11×10^{7} 4. $(5.67 \times 10^{7}) - (45.6 \times 10^{6}) =$

4.83×10^{5} 5. $(6.78 \times 10^{5}) - (432{,}000) + (23.7 \times 10^{4}) =$

1.00×10^{3} 6. $1{,}000 \times 0.000001 \times 10^{6} =$

4.80×10^{1} 7. $0.0005 \times 96{,}000 =$

2.38×10^{3} 8. $0.0000387 \times 10^{-5} \times 0.076 \times 10^{6} \times 81{,}000{,}000 =$

1.14×10^{2} 9. $896{,}100 / 7{,}856 =$

3.71×10^{-5} 10. $0.0002538 / 6.845 =$

4.67×10^{6} 11. $14{,}025{,}320 \times 10^{-12} / 0.0000030027 \times 10^{-6} =$

6.75×10^{7} 12. $\sqrt{456 \times 10^{13}} =$

1.58×10^{2} 13. $\sqrt{25.0 \times 10^{3}} =$

1.93×10^{2} 14. 75.5 % of 256 =

1.09×10^{2} 15. 5.5 % of 1,975 =

4.16×10^{3} 16.
$$\frac{156{,}000 \times 10^{4} \times 704 \times 10^{-6} \times 485{,}000 \times 10^{3}}{573 \times 10^{-8} \times 6.28 \times 10^{12} \times 356{,}178 \times 10^{-2}} =$$

6.47×10^{-1} 17.
$$\frac{0.432 \times 8{,}350{,}000 \times 10^{-3} \times 5.632 \times 10^{3}}{943{,}000 \times 10^{0} \times 6.28 \times 10^{12} \times 0.000000530 \times 10^{-5}} =$$

DIRECTIONS: Write the following using the most suitable metric prefix.

3.3 KΩ 18. 3,300 Ohms

55 MV 19. 55,000,000 Volts

0.5 μH 20. 0.0000005 Henry

6 GHz 21. 6,000,000,000 Hertz

25 mW 22. 0.025 Watt

56 KHz 23. 56,000 Hertz

2 pF 24. 0.000000000002 Farad

3 nSec 25. 0.000000003 Second

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Vocational Industrial Clubs of America
AIMS:	Familiarize students with the purpose and intent of V.I.C.A., and the opportunities and advantages it affords vocational industrial students through participation in its youth leadership, competitive, social, and civic activities.
TEACHING AIDS:	Slide - tape presentation, Developing Leaders for Tomorrow's Industry, Vocational Instructional Services, F.E. Box 182, Texas A&M University, College Station, TX 77843, catalog # 98810, Transparencies 19500, figs. 8-22
MATERIALS:	VICA Brochures
REFERENCES:	Leadership Handbook, Vocational Industrial Clubs of America, Inc., 105 N. Virginia Ave., Falls Church, VA 22046 Everything You Wanted to Know About VICA, catalog # 98301, Constitution and Bylaws, VICA Texas Association, catalog # 98104, Vocational Instructional Services, F.E. Box 182, Texas A&M University, College Station, Texas 77843
PREREQUISITE EXPERIENCE OF THE LEARNER:	None

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Preview slide-tape presentation: Developing Leaders For Tomorrow's Industry

Tell students what to look for! (answer following questions)
What is VICA?
Why should I join?
What can it do for me?

Show presentation!

Ask questions above!

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. VICA is	1. The Vocational Industrial Clubs of America, Inc.

2. Your professional organization
   - a. Designed exclusively for trade and industrial education students
   - b. Operates nationally through the public schools
   - c. Works to build good public relations and elevate the status of all trade, industrial, and technical occupations

B. Why Join VICA?

1. VICA is your opportunity to belong
   - a. To participate in worthwhile activities
   - b. To be a part of
2. VICA offers great leadership development opportunities
3. VICA offers a program of co-curricular activities
   - a. That make education more meaningful
   - b. Thereby improving attitudes and grades
4. VICA offers fellowship; a chance to meet and make new friends
   - a. Through friendly competition
   - b. By bringing together youth sharing common interests

C. Purposes of VICA

1. Unite in a common bond all students of vocational industrial education
2. Develop leadership abilities

Pass Out: VICA Brochure

3. Foster deep respect for the dignity of work
4. Assist students establish realistic vocational goals
5. Help students attain a purposeful life
6. Create enthusiasm for learning

Show: Transparency fig. 8

7. Promote high standards of trade ethics, work quality, scholarship, and safety
8. Develop student abilities to plan, organize, and conduct worthy activities using democratic processes
9. Foster wholesome understanding of the functions of labor and management and the mutual interdependence
10. Create esteem for trade, industrial, technical, and health education
11. Develop patriotism through
    - a. Knowledge of our nation's heritage
    - b. The practice of democracy

D. History and Background

1. Forerunners organized in late 1920's; early 1930's
2. Established to serve needs of vocational, industrial students
3. Foundered/failed due to lack of involvement with industry, depression, war years (1940's)
4. 1950's saw some state organizations revive
   Note: Texas organization called V. I. C. (Vocational Industrial Clubs)
5. 1960's saw movement toward national organization
   a. 1962, 63, 64 plans were contrived
   b. 1965 (14) states including Texas organized nationally and elected first officers
6. The Vocational Industrial Clubs of America was incorporated April 21, 1967

E. Emblem

Show: Transparency fig. 9

1. Is a badge of identify for all VICA members
   a. Worn on all official uniforms
   b. Displayed at all official VICA functions
2. Is composed of symbols representing the purposes and goals of VICA
3. Explain/have members explain symbols
   a. Shield - patriotism
   b. Torch - knowledge
   c. Orbital circles - technology
   d. Gear - industry
   e. Hands - youth
   f. VICA - "Vocational Industrial Clubs of America"
4. Display emblem - use overlay emblem with explanations

F. Colors

1. Represent the national organization
2. Add additional meaning to emblem
3. Explain what colors represent
   a. Red and white - represent the individual states and clubs
   b. Blue - represents the common union of the states and clubs
   c. Gold - represents the individual; the most important element of VICA

G. Motto

1. Recite motto: "Preparing for leadership in the world of work."

Show: Transparency fig. 10	2. Interpret meaning a. Preparing - the act of making ready b. Leadership - the ability to lead or the act of leading c. World of work - the sum total of occupations; in this case, industrial occupations 3. Interpretation - "getting ready today, to be tomorrow's industrial leaders"
H. Pledge Show: Transparency fig. 11	1. Recite pledge! 2. Have students recite pledge! 3. Have students a. Interpret each phrase b. Explain how it relates to them
I. Creed Show: Transparency fig. 12	1. Read creed! One phrase at a time 2. Discuss each phrase with class 3. Have students explain how living by creed can: a. Affect their home life b. Affect their education c. Affect their social life
J. VICA Organization	1. National organization involved with two divisions of vocational industrial education a. Secondary b. Post secondary 2. Operates on four levels: National, State, District, and Local
1. National VICA	1. Governing body composed of: a. State T&I supervisors with VICA associations b. Member from U. S. office of education c. Representatives from AVA
Show: Transparency fig. 13 & 14	2. Is divided into secondary/post secondary: a. Each has own constitution b. Each elects own executive council c. Each conducts own activities 3. Executive council (secondary) is elected annually a. By delegate vote from state associations b. At national convention c. To set policy; conduct official business d. Is composed of President, Vice-President, Secretary, Treasurer, Parliamentarian, Vice-President from each of five regions

4. Advisory council assists board
    a. Counsels, advises
    b. Members are from all facets of education, labor, and business
5. Executive secretary is administrator
    a. Appointed by board
    b. Conducts official business
6. Headquartered in Falls Church, Virginia
7. Sponsors:
    a. National Convention
    b. National Skill Olympics

2. Texas Association

1. Operates with approval of national administrative board

Show: Transparency fig. 15

2. Charter granted upon meeting national qualifications
3. Is administered under State Department of Education
    a. Division of Occupational Education and Technology
    b. Trade and industrial programs
    c. Executive Secretary appointed to administer official business
4. Executive Council - members of local chapters
    a. Elected annually
    b. By delegate vote from local chapters
    c. At state convention and meet
    d. To conduct official state business (VICA)
    e. Consists of President, Vice-President, Secretary, Treasurer, Parliamentarian, Vice-President from each of 13 districts
5. Advisory Council (state)
    a. Counsels, advises, assists executive board
    b. Composed of educators, representatives of business, industry
6. Sponsors:
    a. Leadership Training
    b. State Meet
    c. State Convention

3. Areas

Show: Transparencies fig. 16 & 17

1. Number (13) in the state (Texas)
2. Area consultant (Texas Education Agency) is VICA administrator for his/her area

3. Executive council
    - a. Is elected annually
    - b. By delegate vote from local chapters
    - c. At area meet
    - d. To conduct official area business (VICA)
    - e. Consists of President, Vice-President, Secretary, Treasurer

4. Advisory council
    - a. Counsels, advises, assists
    - b. Composed of officers local chapter advisor, representative from TEA (area consultant)

5. Sponsors
    - a. Fall leadership training
    - b. District meet

4. Local

1. Backbone of total VICA program
    - a. Organized through public school regular pre-lab, coop, vocational industrial education classes
    - b. Petition to state chapter for charter

Show: Transparency fig. 18

2. Club organizational structure
    - a. Club advisor - class instructor
    - b. Club advisory - local representatives from business, industry, education
    - c. Officers - local election (within club)
    - d. Delegates - district; state
    - e. Members - qualified vocational industrial education students

K. Personal Development

1. Leadership training
    - a. Serve as officer of local, district, state chapter, national organization
    - b. Leadership training conferences at district, state, and national level
    - c. Serve on committees as member or chairperson

2. Participate in civic activities
    - a. Service to school
    - b. Service to community

3. Participate in social activities

4. Participate in competitive activities
    - a. Individual events
    - b. Skill events
    - c. Student selected job
    - d. Chapter events

L. Vocational Initiative and Club Achievement Program

1. Provide recognition for student performance
2. Stimulate desire for excellence both in skill and leadership areas

Show: Transparency fig. 19

3. Administered by any nationally chartered local VICA club
4. Under supervision of local club's advisory council and local chapter advisor (instructor)
5. Is divided into two categories of achievement
   a. Industrial degree
   b. Leader degree

1. Industrial Degree "Vocational Initiative"

1. Emphasizes technical knowledge, skill proficiency, work habits and traits, preparation for successful job performance
2. Has four classifications
   a. Trainee - vocational class (primary)
   b. Operator - industrial classification
   c. Specialist - career classification
   d. Expert - advanced classification
3. Has insignia of rank with each classification
4. "VICA Industrial Degree" highest category

2. Leader Degree "Club Achievement"

1. Stresses attributes of good citizenship and character
2. Includes participation in club activities - educational, professional, civic, social
3. Emphasis placed on:
   a. Ability to speak
   b. Good citizenship
   c. Leadership

Show: Transparency fig. 20

4. Also has four classifications
   a. Citizen - voice classification (primary)
   b. Committeeman - inter - community classification
   c. Leader - civic classification
   d. Patriot - advanced classification
5. "VICA Leader Degree" is highest in category

3. American VICA Degree

1. Must have completed both "Industrial Degree" and "Leader Degree"
2. Application and review examination are required

Show: Transparency fig. 21

3. Degree carries insignia of VICA emblem with eagle over it

II. PRESENTATION (CONT'.)

4. International Industrial Degree

Show: Transparency fig. 22

1. Must hold American VICA degree
2. Must meet requirements of degree
   a. Employment
   b. Professionalism
   c. Civic service
3. Carries insignia of VICA emblem, eagle, world

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Pass Out: VICA Leadership Handbooks

Rap Session: Purposes of VICA

Have a student read a purpose to class.
Have same student explain what that purpose means to him/her.
Have other students comment.
(Read, explain, comment on all purposes.)

VICA Motto

Have class recite "motto" in unison.
Ask for student comments, interpretation of motto.
Class discuss "motto".

VICA Pledge

Have class recite "pledge" in unison.
Have different student interpret each phrase of pledge.
Class discuss each phrase.

VICA Creed

Have different student read each part of "creed".
Have student explain, in his/her own words, meaning of each part.
Class comment on each part.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Multiple Choice

1. VICA was designed: d
   a. For all vocational students.
   b. To teach vocational students social amenities.
   c. To offer competitive skills to vocational students.
   d. Exclusively for trade and industrial education students.

2. Vocational industrial students should join VICA because it is: a

   a. A greater opportunity "to belong".
   b. Your chance to "build projects you like".
   c. A good way to "make school trips".
   d. The best way to "please the instructor".

3. Vocational Industrial Clubs of America was incorporated on: d

   a. July 4, 1947.
   b. August 4, 1953.
   c. October 27, 1961.
   d. April 21, 1967.

4. In the VICA emblem, the torch represents: b

   a. Patriotism.
   b. Knowledge.
   c. Industry.
   d. Youth.

5. Of the VICA colors, the one which represents the individual is: d

   a. Red.
   b. White.
   c. Blue.
   d. Gold.

6. "Preparing for leadership in the world of work" is the VICA: a

   a. Motto.
   b. Pledge.
   c. Creed.
   d. Purposes.

7. In VICA, Texas Association there are: c

   a. Six areas.
   b. Nine areas.
   c. Thirteen areas.
   d. Fifteen areas.

8. The official VICA administrator of each area is: b

   a. Elected annually by members.
   b. T. E. A. area consultant.
   c. A local chapter advisor appointed by T. E. A.
   d. Not an official position.

9. In the VICA "Vocational Initiative Program" the primary classification is: a

   a. Trainee.
   b. Operator.
   c. Citizen.
   d. Committeeman.

10. The highest category in "Club Achievement" is: c

a. Expert.
b. Patriot.
c. VICA Leader Degree.
d. VICA Industrial Degree.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Vocational Industrial Clubs of America was organized to provide a common bond between all vocational industrial students and to provide opportunities for the complete development of these students through leadership training, skills competition, and opportunities to work with and serve others.

In the VICA structure the local chapters are the backbone of the organization which also functions at district, state, and national levels. It not only provides the student the means and opportunities for industrial achievement, but also provides qualified people to counsel, guide, and assist them in their efforts.

The Vocational Initiative and Club Achievement Program is devised to provide recognition for student performance and to stimulate a desire for excellence in both skill and leadership.

The program has two separate degrees, "Industrial Degree" and "Leader Degree", each having four classifications (ranks) to be earned, and all leading to the "American VICA Degree"; the highest degree obtainable by a student.

The "Industrial Degree" emphasizes technical knowledge, skill proficiency, work habits and traits, and preparation for successful job performance.

The "Leader Degree" stresses attributes of good citizenship, the ability to speak, interest and participation in social, civic, professional affairs, and practices in democracy.

Participation in VICA can only be a plus - an asset to the education and maturing process of any student qualified to join.

THE NEXT UNIT IS: Organize Local VICA Club

LEADERSHIP DEVELOPMENT

PURPOSES OF VICA

○ UNITY

○ LEADERSHIP ABILITY

○ RESPECT FOR THE DIGNITY OF WORK

○ VOCATIONAL GOALS

○ PURPOSEFUL LIFE

○ ENTHUSIASM FOR LEARNING

○ HIGH STANDARDS IN WORKMANSHIP

○ PLANNING AND WORKING TOGETHER

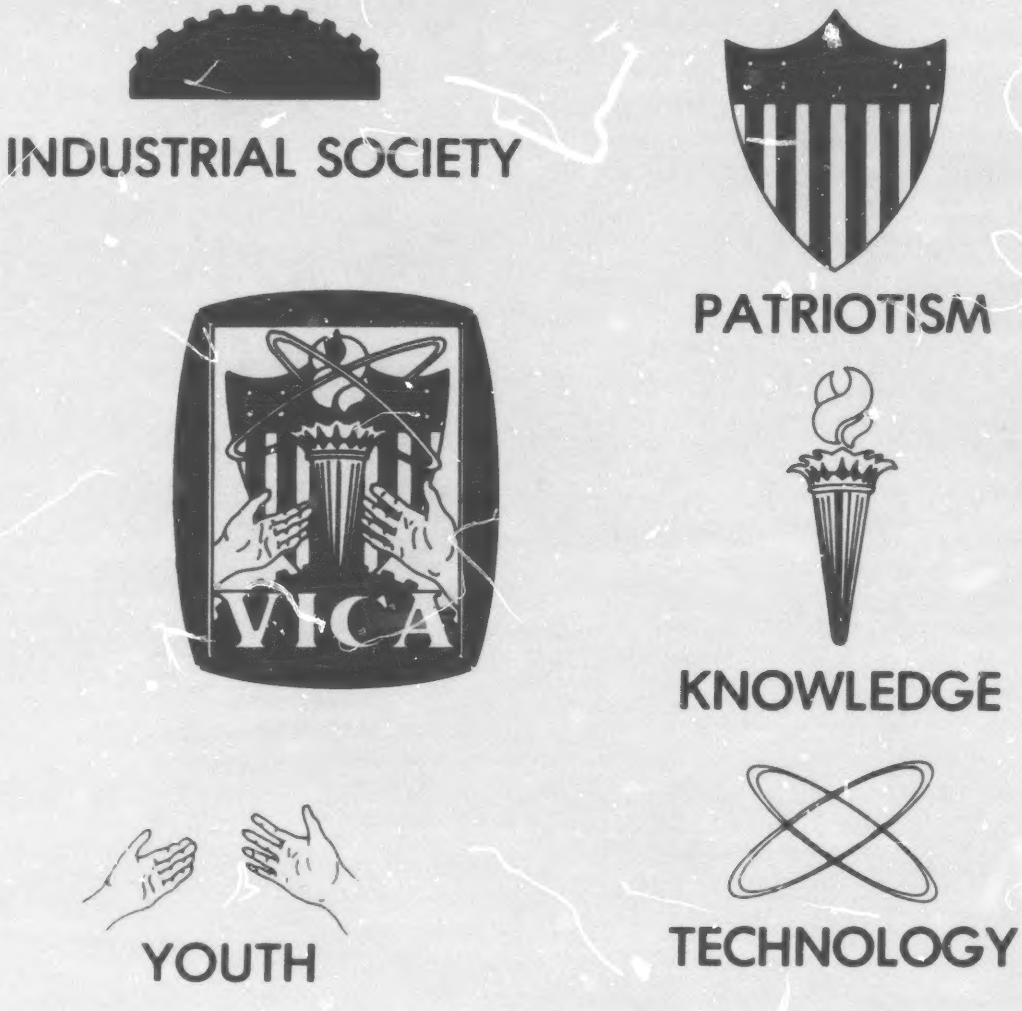
○ UNDERSTANDING LABOR AND MANAGEMENT

○ ESTEEM FOR THE WORLD OF WORK

○ PRACTICE OF DEMOCRACY

LEADERSHIP DEVELOPMENT

VICA EMBLEM

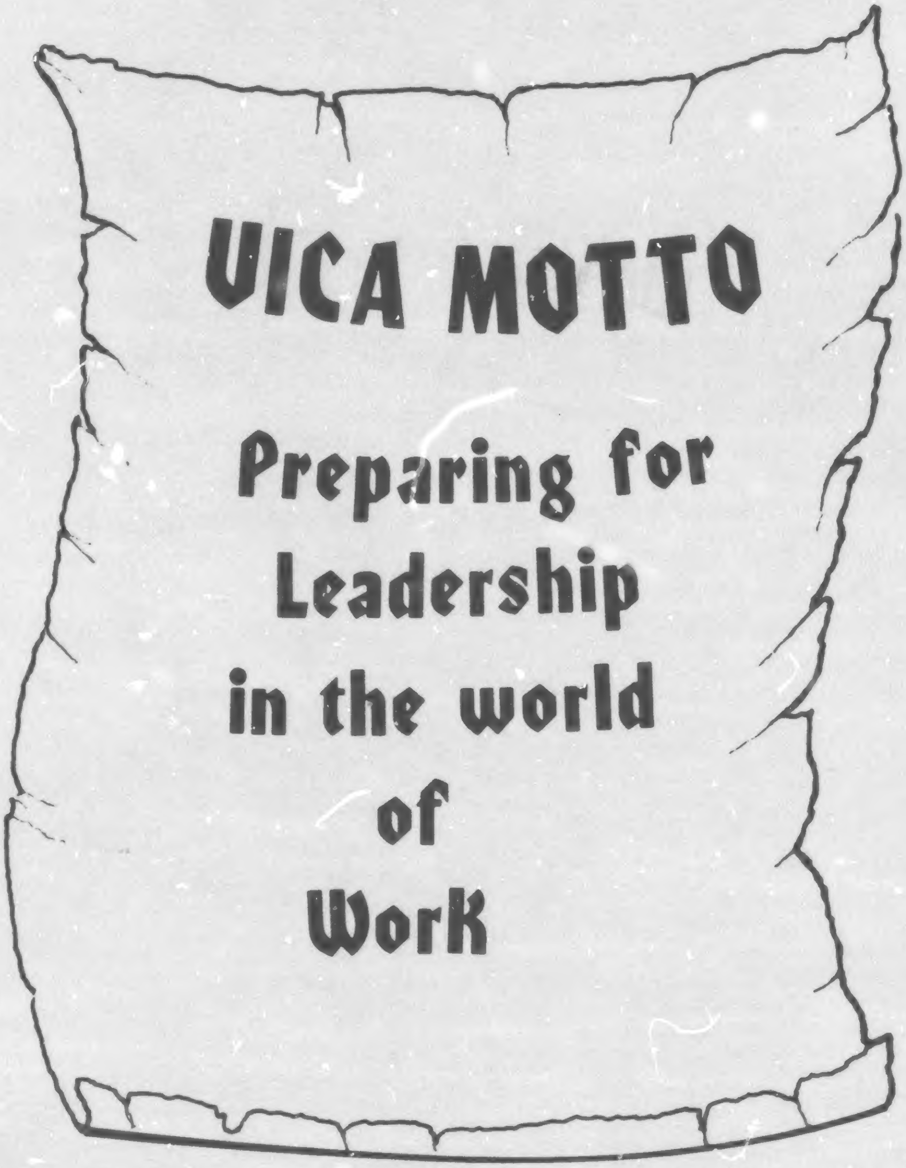

INDUSTRIAL SOCIETY
PATRIOTISM
VICA
KNOWLEDGE
YOUTH
TECHNOLOGY

VICA

VOCATIONAL INDUSTRIAL CLUBS
OF AMERICA

Fig. 9

LEADERSHIP DEVELOPMENT



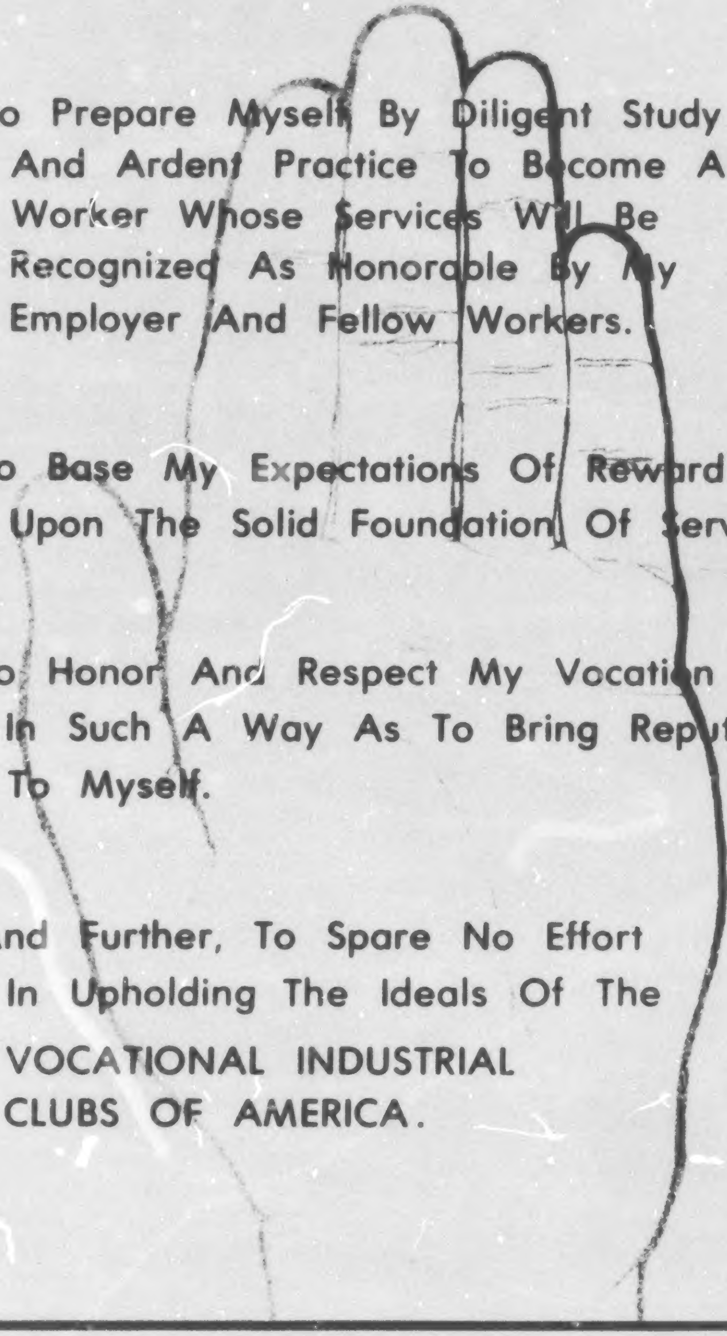
VICA MOTTO

Preparing for
Leadership
in the world
of
Work

Fig. 10

LEADERSHIP DEVELOPMENT

VICA PLEDGE



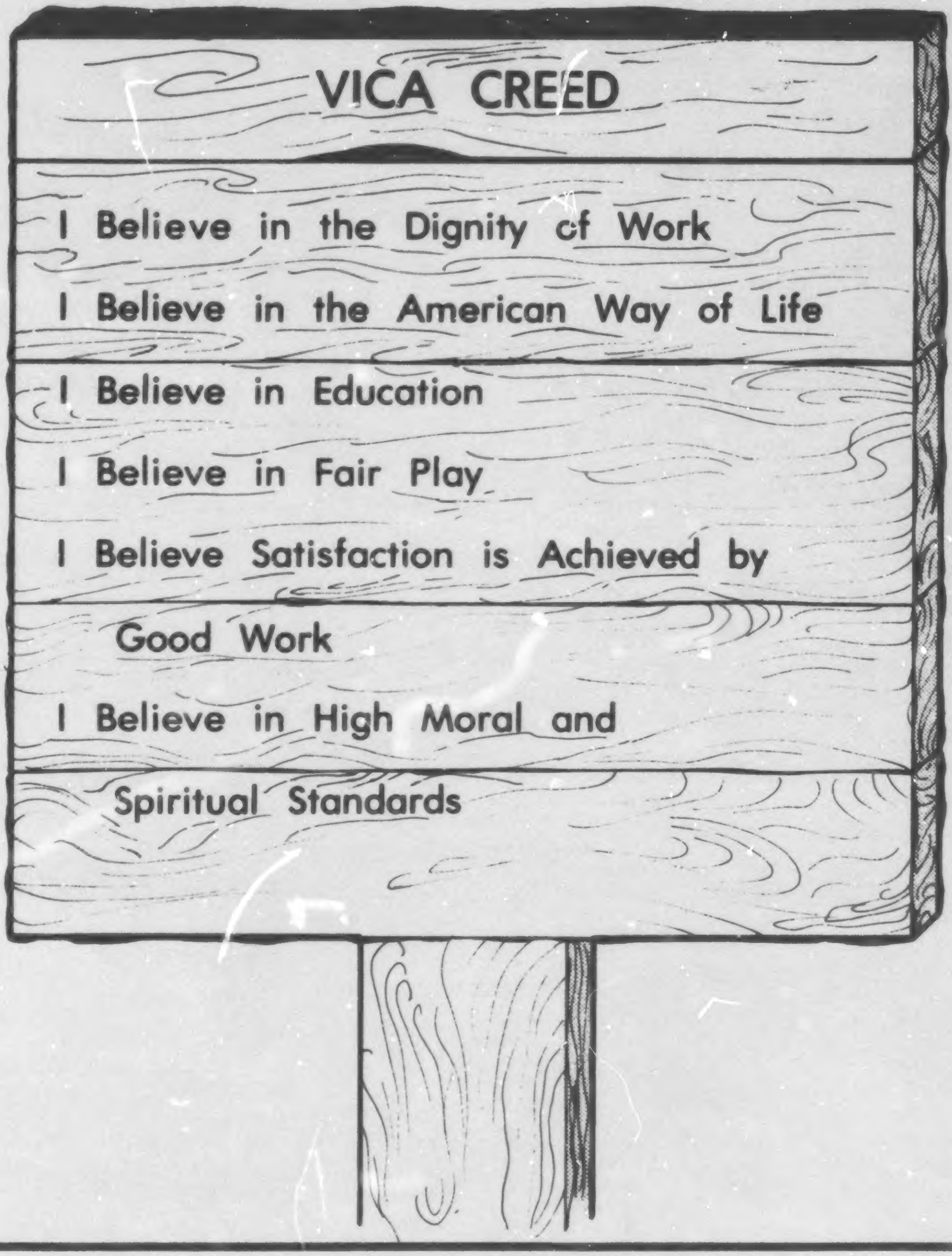
To Prepare Myself By Diligent Study
And Ardent Practice To Become A
Worker Whose Services Will Be
Recognized As Honorable By My
Employer And Fellow Workers.

To Base My Expectations Of Reward
Upon The Solid Foundation Of Service.

To Honor And Respect My Vocation
In Such A Way As To Bring Repute
To Myself.

And Further, To Spare No Effort
In Upholding The Ideals Of The
VOCATIONAL INDUSTRIAL
CLUBS OF AMERICA.

LEADERSHIP DEVELOPMENT



VICA CREED

I Believe in the Dignity of Work

I Believe in the American Way of Life

I Believe in Education

I Believe in Fair Play

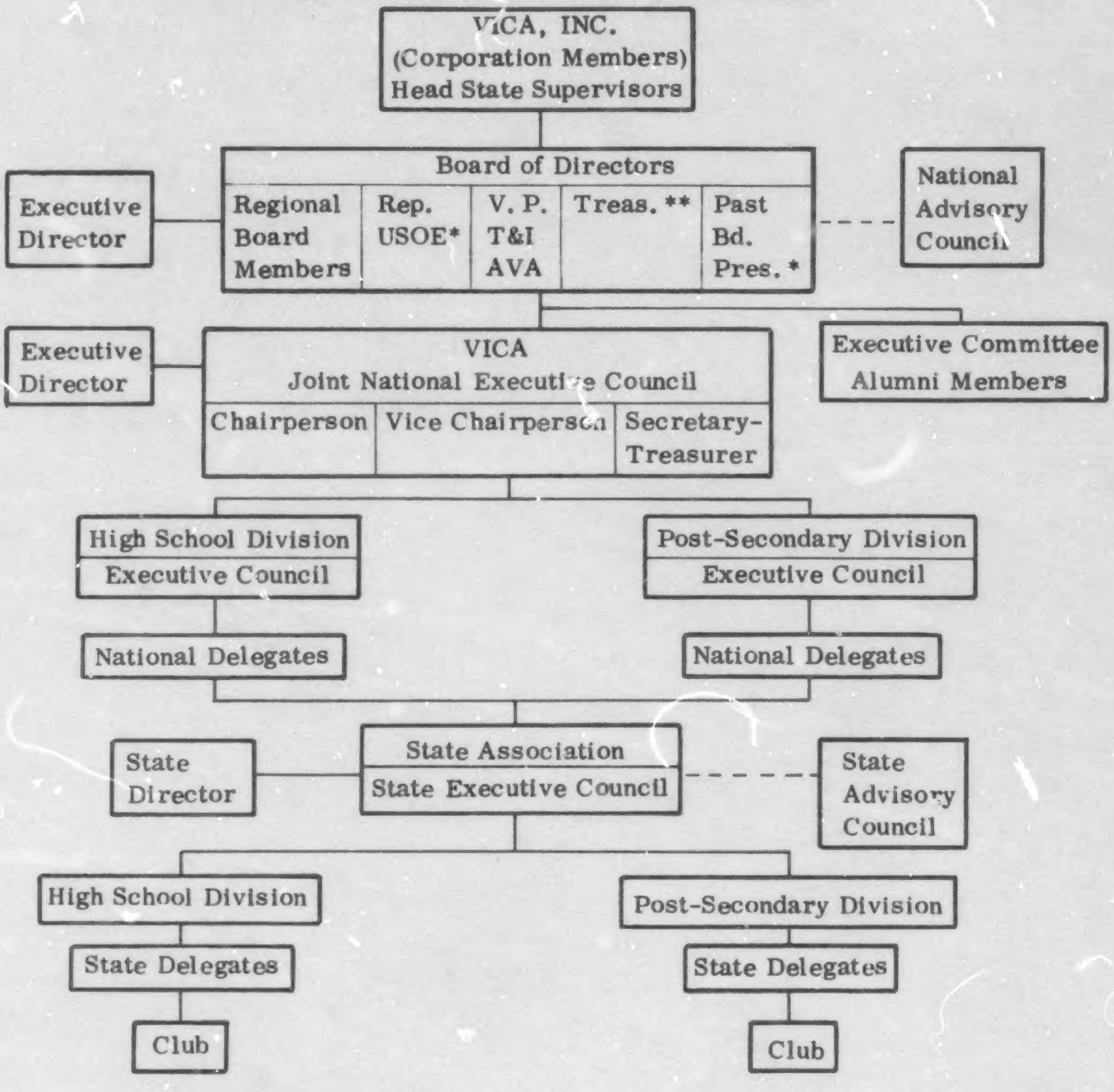
I Believe Satisfaction is Achieved by Good Work

I Believe in High Moral and Spiritual Standards

Fig. 12

LEADERSHIP DEVELOPMENT

VOCATIONAL INDUSTRIAL CLUBS OF AMERICA NATIONAL STRUCTURE


VICA, INC.
(Corporation Members)
Head State Supervisors
Board of Directors
Regional Board Members
Rep. USOE*
V. P. T&I AVA
Treas. **
Past Bd. Pres. *
Executive Director
National Advisory Council
VICA
Joint National Executive Council
Chairperson
Vice Chairperson
Secretary-Treasurer
Executive Director
Executive Committee
Alumni Members
High School Division
Executive Council
Post-Secondary Division
Executive Council
National Delegates
National Delegates
State Association
State Executive Council
State Director
State Advisory Council
High School Division
Post-Secondary Division
State Delegates
State Delegates
Club
Club

* Ex Officio

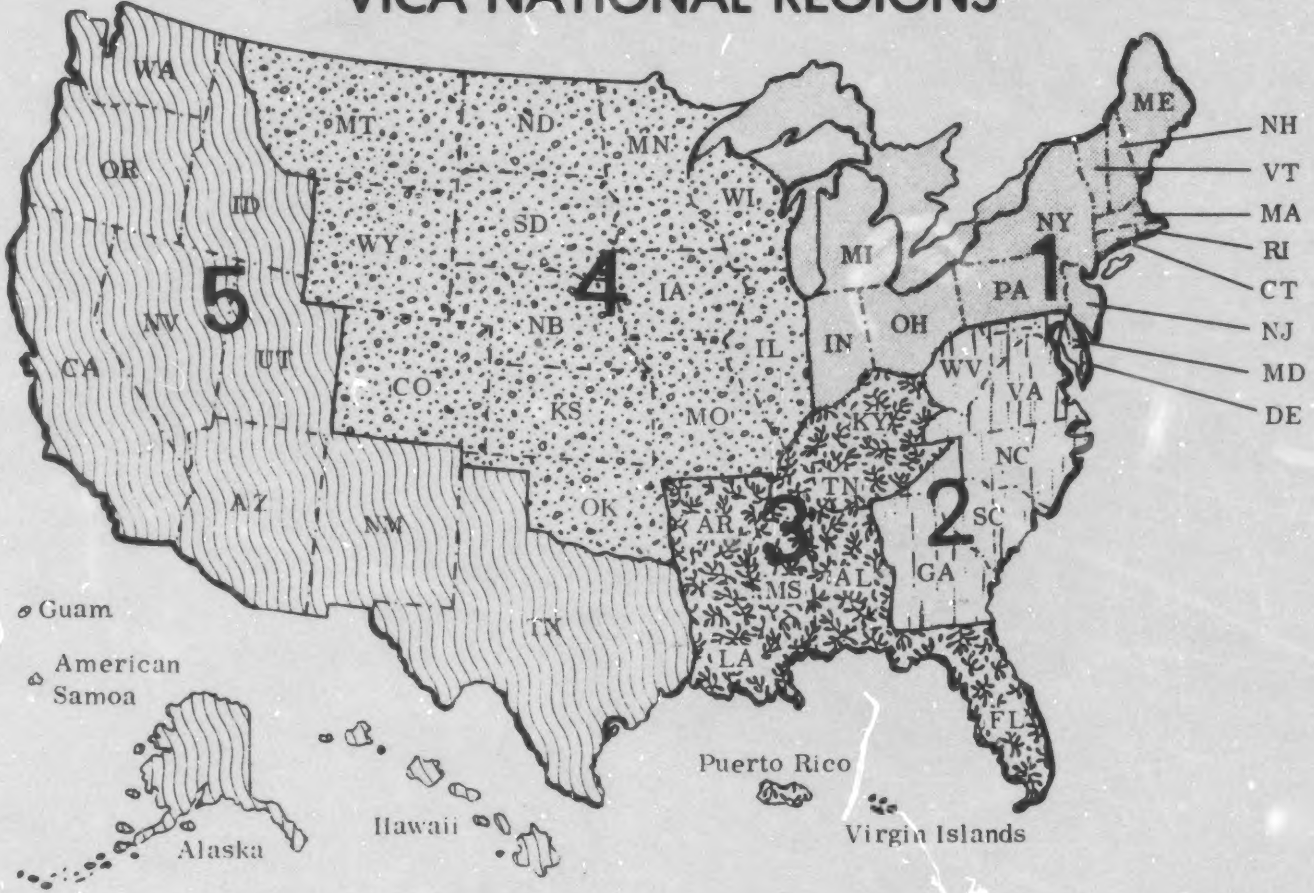
** Employee of the Board

——— Administrative

------- Advisory

Fig. 13

VICA NATIONAL REGIONS



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MD
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Guam
American Samoa
Alaska
Hawaii
Puerto Rico
Virgin Islands

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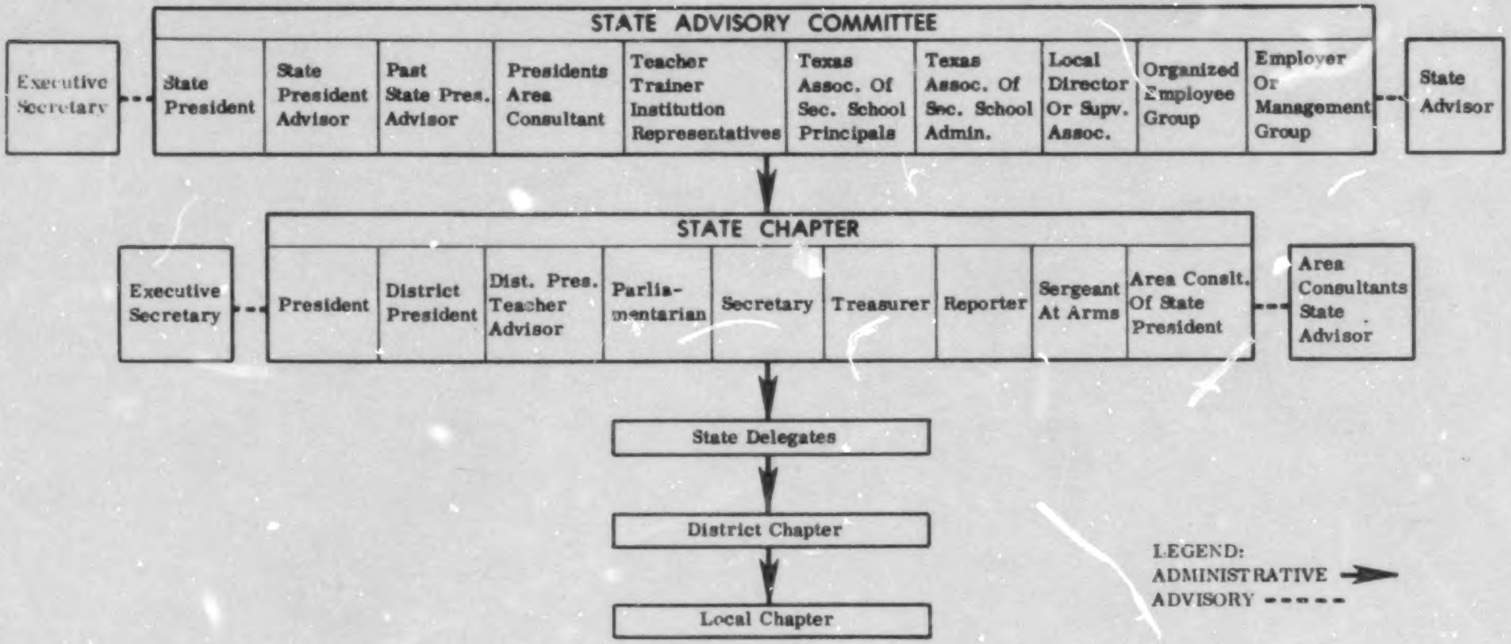
LEADERSHIP DEVELOPMENT

VOCATIONAL INDUSTRIAL CLUBS OF AMERICA
STATE ORGANIZATION



STATE ADVISORY COMMITTEE

Executive Secretary

State President

State President Advisor

Past State Pres. Advisor

Presidents Area Consultant

Teacher Trainer Institution Representatives

Texas Assoc. Of Sec. School Principals

Texas Assoc. Of Sec. School Admin.

Local Director Or Supv. Assoc.

Organized Employee Group

Employer Or Management Group

State Advisor

STATE CHAPTER

Executive Secretary

President

District President

Dist. Pres. Teacher Advisor

Parliamentarian

Secretary

Treasurer

Reporter

Sergeant At Arms

Area Consit. Of State President

Area Consultants State Advisor

State Delegates

District Chapter

Local Chapter

LEGEND:
ADMINISTRATIVE ➔
ADVISORY - - - - -

Fig. 15

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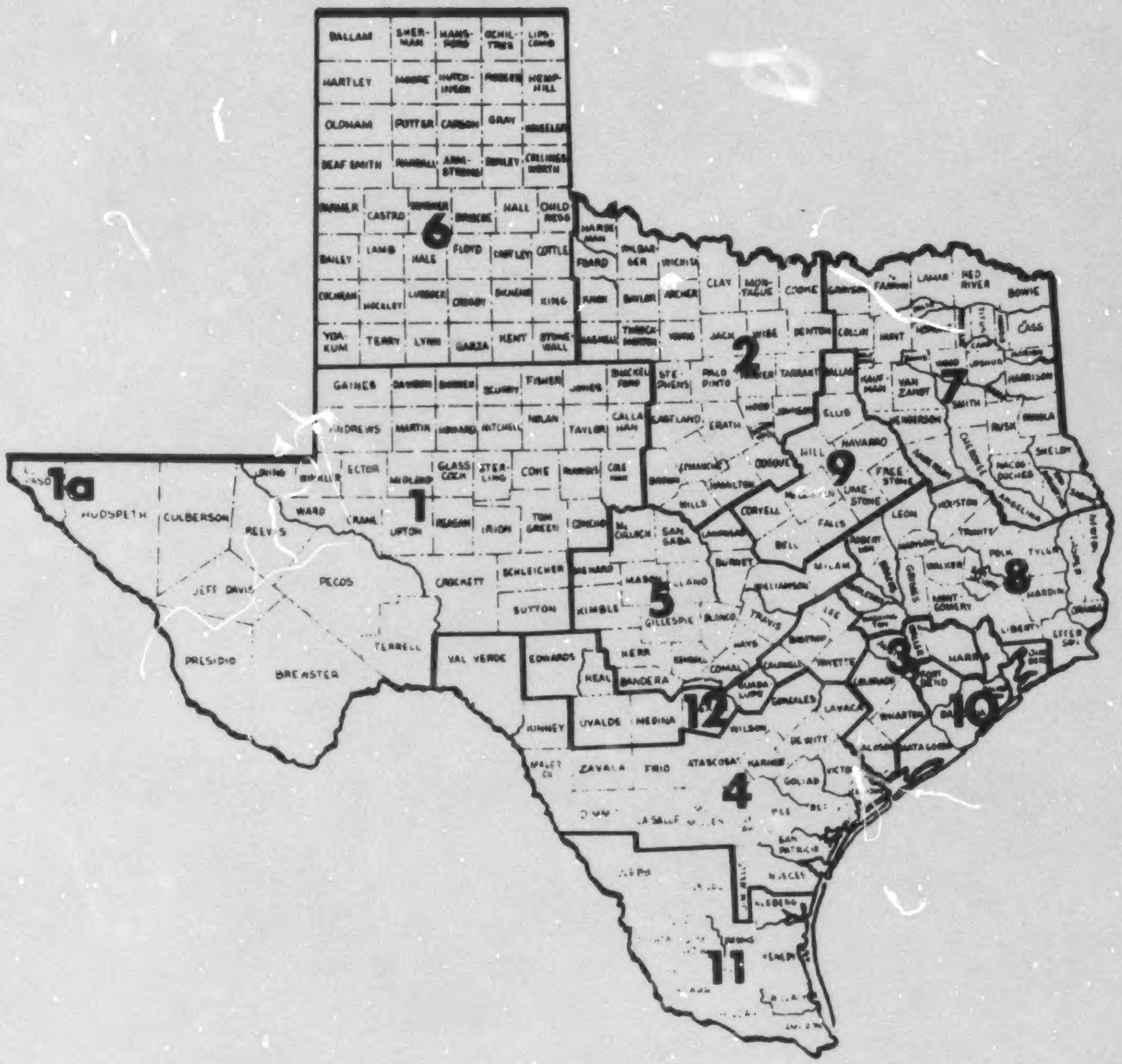
LEADERSHIP DEVELOPMENT

VICA TEXAS DISTRICTS



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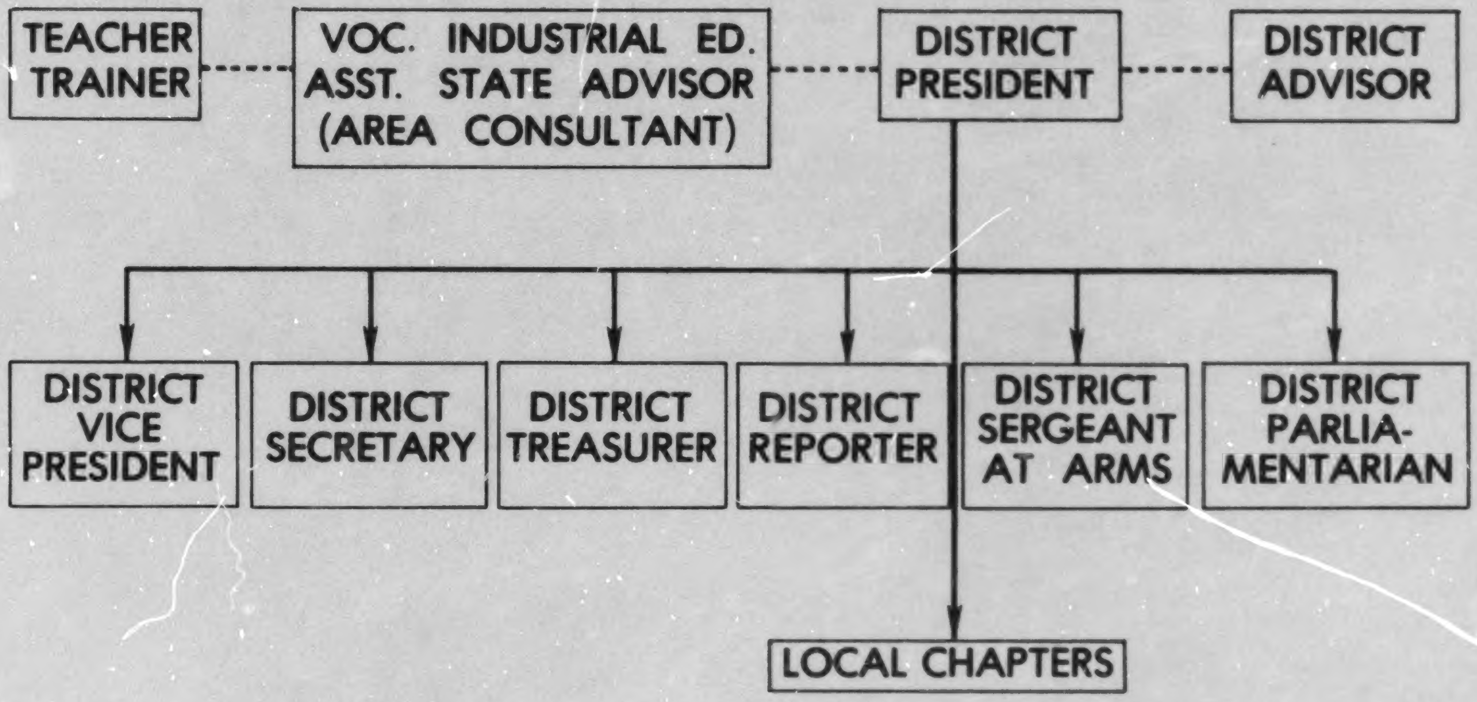
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
HARTLEY
MOORE
HUTCHINSON
HEMPHILL
OLDHAM
POTTER
CARSON
GRAY
WHEELER
DEAF SMITH
ARMSTRONG
DONLEY
COLLINGSWORTH
PARMER
CASTRO
SWISHER
BRISCOE
HALL
CHILDRESS
BAILEY
LAMB
HALE
FLOYD
COTTLE
COCHRAN
HOCKLEY
LUBBOCK
CROSBY
KING
YOAKUM
TERRY
LYNN
GARZA
KENT
STONEWALL
GAINES
SCURRY
FISHER
JONES
SHACKELFORD
ANDREWS
MARTIN
HOWARD
MITCHELL
NOLAN
TAYLOR
CALLAHAN
ECTOR
MIDLAND
GLASSCOCK
STERLING
COKE
WARD
CRANE
UPTON
REAGAN
IRION
TOM GREEN
CONCHO
CROCKETT
SCHLEICHER
SUTTON
HUDSPETH
CULBERSON
REEVES
JEFF DAVIS
PECOS
PRESIDIO
BREWSTER
TERRELL
VAL VERDE
EDWARDS
KINNEY
UVALDE
MEDINA
ZAVALA
FRIO
ATASCOSA
KARNES
GOLIAD
DIMMIT
LA SALLE
NUECES
SAN PATRICIO
KLEBERG
HARDEMAN
WILBARGER
WICHITA
CLAY
MONTAGUE
COOKE
FOARD
BAYLOR
ARCHER
THROCKMORTON
YOUNG
JACK
WISE
DENTON
STEPHENS
PALO PINTO
TARRANT
EASTLAND
ERATH
HOOD
COMANCHE
HAMILTON
CORYELL
MILLS
BELL
FALLS
MC CULLOCH
SAN SABA
MASON
LLANO
KIMBLE
GILLESPIE
BLANCO
KERR
BANDERA
REAL
COMAL
HAYS
TRAVIS
GUADALUPE
GONZALES
WILSON
DE WITT
LAVACA
FAYETTE
LEE
MILAM
WILLIAMSON
BURNET
GRAYSON
FANNIN
LAMAR
RED RIVER
BOWIE
COLLIN
HUNT
CASS
KAUFMAN
VAN ZANDT
SMITH
HARRISON
RUSK
PANOLA
SHELBY
HENDERSON
CHEROKEE
NACOGDOCHES
ELLIS
HILL
NAVARRO
LIMESTONE
FREESTONE
LEON
HOUSTON
TRINITY
POLK
TYLER
WALKER
MONTGOMERY
HARDIN
LIBERTY
HARRIS
FORT BEND
WHARTON
MATAGORDA
CALHOUN
VICTORIA

Fig. 16

LEADERSHIP DEVELOPMENT

DISTRICT CHAPTER



TEACHER TRAINER

VOC. INDUSTRIAL ED. ASST. STATE ADVISOR (AREA CONSULTANT)

DISTRICT PRESIDENT

DISTRICT ADVISOR

DISTRICT VICE PRESIDENT

DISTRICT SECRETARY

DISTRICT TREASURER

DISTRICT REPORTER

DISTRICT SERGEANT AT ARMS

DISTRICT PARLIAMENTARIAN

LOCAL CHAPTERS

LEADERSHIP DEVELOPMENT

LOCAL CHAPTER

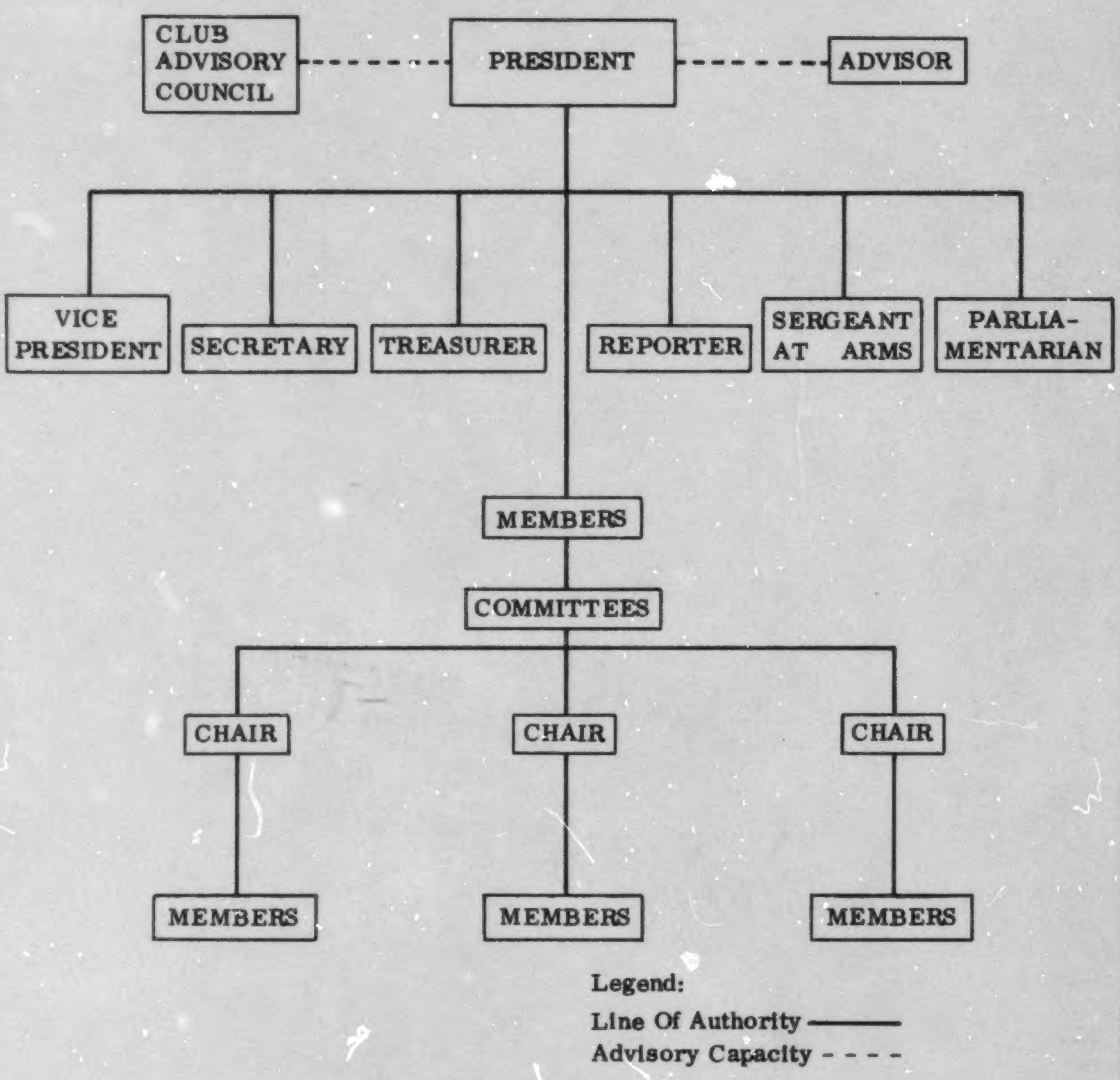

CLUB ADVISORY COUNCIL
PRESIDENT
ADVISOR
VICE PRESIDENT
SECRETARY
TREASURER
REPORTER
SERGEANT AT ARMS
PARLIAMENTARIAN
MEMBERS
COMMITTEES
CHAIR
CHAIR
CHAIR
MEMBERS
MEMBERS
MEMBERS
Legend:
Line Of Authority ———
Advisory Capacity - - - -

Fig. 18

LEADERSHIP DEVELOPMENT

VOCATIONAL INITIATIVE PROGRAM SKILL

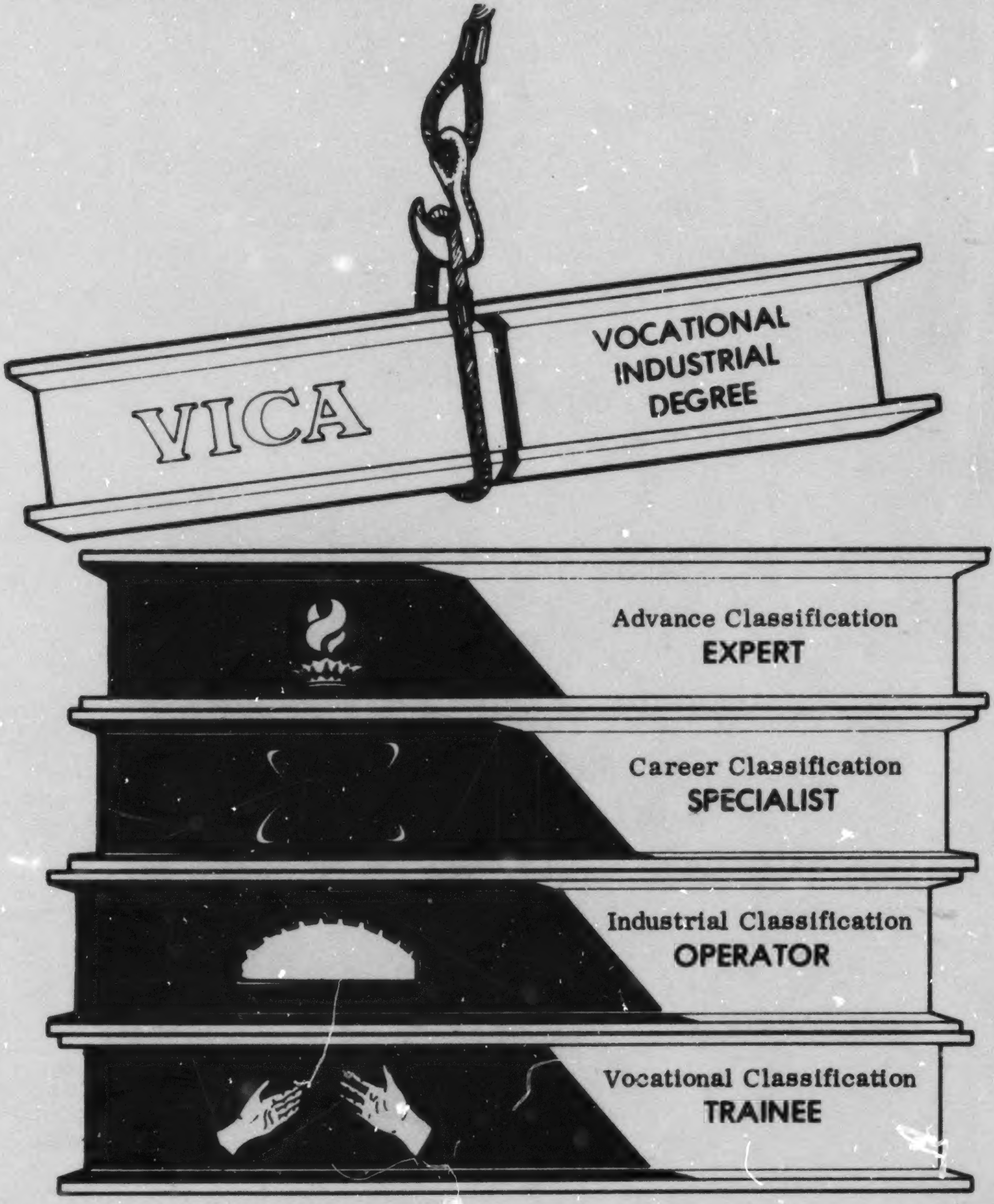
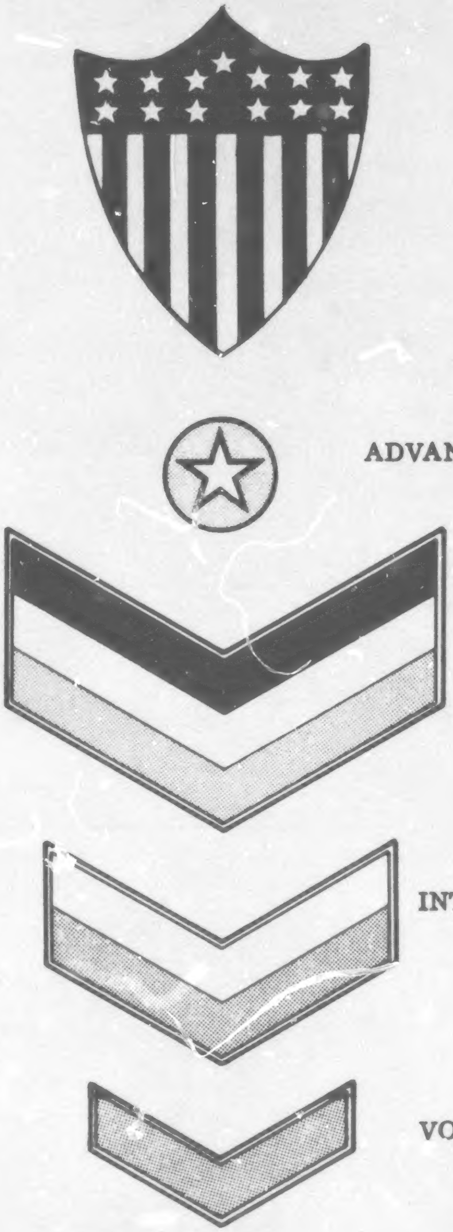

VICA
VOCATIONAL
INDUSTRIAL
DEGREE
Advance Classification
EXPERT
Career Classification
SPECIALIST
Industrial Classification
OPERATOR
Vocational Classification
TRAINEE

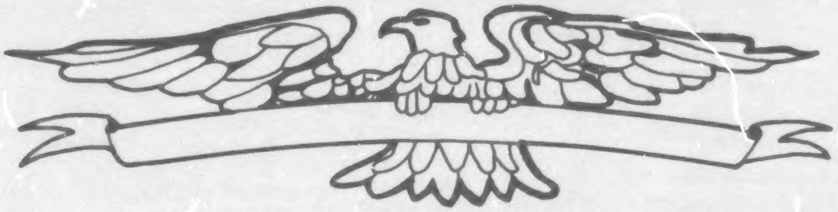
Fig. 19

VOCATIONAL ACHIEVEMENT LEADERSHIP PROGRAM


VICA LEADER DEGREE
ADVANCE CLASSIFICATION
PATRIOT
CIVIC CLASSIFICATION
LEADER
INTER-COMMUNITY CLASSIFICATION
COMMITTEE MEMBER
VOICE CLASSIFICATION
CITIZEN

LEADERSHIP DEVELOPMENT

THE AMERICAN VICA DEGREE



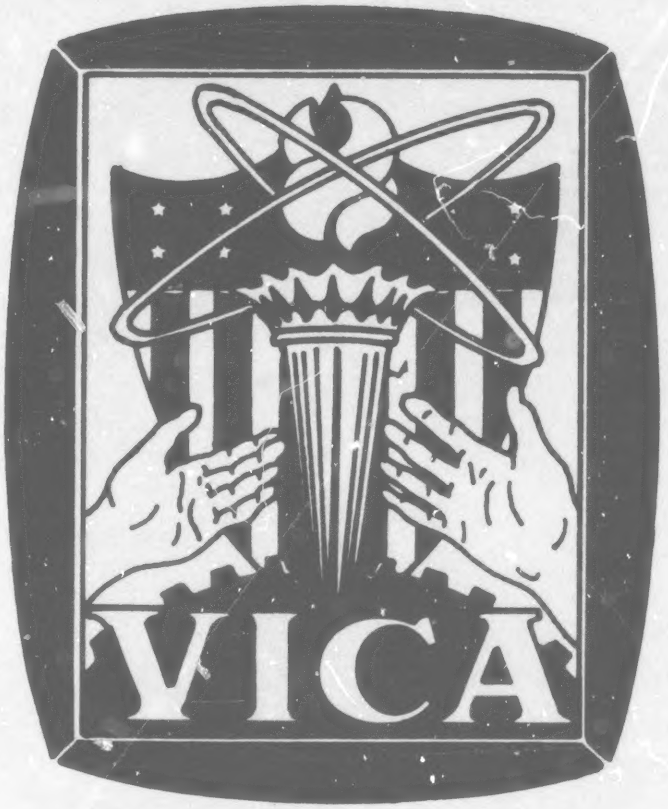


Fig. 21

LEADERSHIP DEVELOPMENT

THE INTERNATIONAL INDUSTRIAL DEGREE

Fig. 22

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Organize Local VICA Club
AIMS:	The student will understand the procedures and be able to participate in the processes involved with organizing a VICA club.
TEACHING AIDS:	O/H projector, Transparencies 19500, figs. 23-27 slide projector, slide-tape presentation, VICA, Developing Leaders for Tomorrow's Industry
REFERENCES:	Leadership Handbook, Vocational Industrial Clubs of America Everything You Wanted to Know About VICA Texas VICA Competitive Activities Guide Constitution and Bylaws, VICA Texas Association Initiation Ritual Official Officer Installation Handbook for Reporters Secretary's Notebook Treasurer's Notebook
PREREQUISITE EXPERIENCE OF THE LEARNER:	The student must be officially enrolled in a regular vocational industrial program and have successfully completed previous lesson I-D-1(I).

I. PREPARATION (OF THE LEARNER - MOTIVATION

In discussing VICA, it is evidenced that VICA was created as a vehicle to more completely develop the vocational student as a skilled craftsperson and as a conscientious, productive citizen.

Through a planned program of cocurricular activities, and under the guidance and advice of experienced counsel, the student is exposed to activities, both competitive and social. Activities that foster good work habits and a deep respect for the dignity of work. Activities designed to create enthusiasm for learning; planning, organizing, and conducting worthy activities that, in essence, make all education more meaningful.

The vehicle is there! It is up to you, and me, to jump on it and ride it for all it's worth.

II. PRESENTATION (OF THE INFORMATION)

	INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A.	Ingredients for a Good Club	1. 100% active membership
Show:	Transparency fig. 23	2. An enthusiastic advisor
		3. Qualified officers
		4. Active committees a. Chairperson b. Committee members
		5. Calendar of events
		6. Constitution and bylaws
		7. Energetic advisory committee
B.	Organize the Club	Note: The following is directed to programs without VICA clubs; however, much of this information may also be applied to recruitment and perpetuation of existing clubs
	1. Stimulate Interest	1. Among students in program
		2. Display VICA posters, emblem, signs
		3. Show: slide-tape presentation, # 98810 a. Preview presentation b. Tell students what to look for in presentation c. Show presentation d. Discuss presentation
		4. Invite guest speakers a. Officers from neighboring club b. Informal talk on what VICA did for them
		5. Encourage students - familiarize them with the purposes and functions of VICA
	2. Committee to Organize	Refer: Leadership Handbook
		1. Stimulate interest among key students a. Familiarize with club work and operation b. Discussion with officers of existing club
		2. Form a committee to organize a. Elect a chairperson b. Plan strategies c. Delegate duties
		3. Call organization meeting
		4. Propose organizing VICA club a. Why join VICA? b. How it operates? c. Purposes!

5. Discuss:
   - a. Activities for club
   - b. Recreation and fellowship
   - c. Competitive and leadership training
   - d. Should we organize?
   - e. State and national constitutions

   Note: If group decides to organize

3. Adopt Local Constitution

1. Appoint/elect committee to draft constitution
   - a. Members must be interested
   - b. Members must be serious
2. Discuss state and national constitutions
   - a. Members take notes
   - b. Pattern local after state/national
3. Draft local constitution

   Refer: Secretary's Notebook
   - a. Appoint recording secretary
   - b. Secretary record formal draft
4. Present draft to interested group
5. Have group ratify constitution

C. Elect Officers

Note: Once constitution is adopted, chairperson calls for election of officers

1. Qualities Desired

Show: Transparency fig. 24

1. Vigorous and energetic in carrying out the duties and responsibilities of office
2. Impartial in performing job as an officer
3. Cooperative with other officers, advisors, fellow members

2. Duties and Responsibilities

Show: Transparency fig. 25

1. President is the key to organizational leadership
   - a. Keeps well informed about club activities
   - b. Presides over all meetings
   - c. Recognizes what must be done
   - d. Is able to work with, and convince, people
   - e. Has ability to delegate authority
   - f. Must judge impartially
   - g. Understands duties of each elected official
2. Vice-President assists president
   - a. Presides at meetings in absence of president
   - b. Assists and counsels with president
   - c. Possesses same leadership qualities as president
   - d. Is ex officio member of all committees
   - e. Responsible for program planning

3. Secretary is custodian of records and president's lifeline of communication
   Refer: Secretary's Notebook
   a. Must be well organized
   b. Good listener, able to interpret and take notes accurately
   c. Keeps records of all club actions
   d. Maintains membership; committee lists
   e. Reads all club correspondence to members and returns correspondence as directed
   f. Furnishes president with agenda for club meetings
4. Treasurer is the banker and custodian of the chapter funds
   Refer: Treasurer's Notebook
   a. Must be accurate in math
   b. Must be dependable
   c. Keeps accounts, records up to date
   d. Sends out membership notices, collects dues, and writes receipts
   e. Pays approved bills
   f. Keeps accounts balanced and up to date
   g. Assists in making annual budget
5. Reporter is the P. R. person for the club
   Refer: Handbook for Reporters
   a. Informs public of chapter activities
   b. Plans and directs chapter displays
   c. Prepares and distributes news releases to local news media
   d. Chairs, or works with, chapter notebook committee
   e. Must have a "nose" for news
   f. Must be able to get along with people
   g. Must be creative; able to write news articles
6. Parliamentarian is president's consultant on procedural matters
   a. Must know parliamentary procedure
   b. Must have the confidence of others
   c. Serves as source for parliamentary information during meetings
      (1) Calls attention to errors in procedure
      (2) Gives opinions based on parliamentary law

7. Sergeant-at-arms' duties include:
    - a. Arrange meeting room and take care of chapter equipment
    - b. Responsible for comfort of those attending meeting
    - c. Attend door at meetings and greet guests
    - d. Take charge of initiates before and during initiation
    - e. Assist with details of program or activity

3. Nomination and Election

1. Explain nomination procedures
2. Select a committee to conduct elections and count ballots
3. Review duties and responsibilities of each office prior to nominations
4. Open floor for nominations (president first)
5. Close nominations
6. Candidates make brief campaign speech
7. Remove candidates from voting ares (if vote is by roll call or show of hands)
8. Vote on candidates
9. Tabulate votes
10. Announce president-elect

Note: President-elect conducts election of other officers

D. Officer Installation

Refer: Official Officer Installation Ceremony

1. Select installation ceremony team
    - a. New club invite officers from existing club
    - b. Organized club use outgoing officers
2. Select site and date
    - a. Appropriate size, setting
    - b. Convenient time, location
3. Invite guests - administrators, parents, other teachers
4. Set up paraphernalia required for ceremony
5. Rehearse ceremony before installation
6. Conduct installation ceremony

E. Member Initiation

Refer: Initiation Ritual

1. Appoint intitation committee to:
    - a. Collect dues from members
    - b. Check qualifications of initiates
    - c. Plan and organize initiation activities

2. Organize initiation team - 10
    a. Club officers and members
    b. Are responsible to set up paraphernalia and conduct initiation

Note: Again, a new club may invite an organized club to perform initiation ritual

3. Rehearse ritual!
4. Conduct initiation!

F. Petition for Charter

1. Obtain petition from state office (state VICA executive secretary)
2. Petition completed by secretary
    a. Includes membership list; dues
    b. Is signed by club president and club advisor
3. Submit petition to state office for processing
4. State office processes petition for national membership
5. Upon acceptance club will receive:
    a. Charter
    b. Charter number
    c. Creed
    d. Pledge
    e. Membership cards

G. Committees

1. Are an integral part of the club organization and structure
2. Are of two types
    a. Standing committees
    b. Special committees
3. Provide means for distribution of work
4. Provide division of power

1. Standing Committees

1. Are established by chapter's Constitution and By-Laws
2. Carry out chapter's permanent (on-going) program of work
3. Types of standing committees:
    a. Program - plans and prepares chapter's program each meeting. Generally chaired by chapter secretary
    b. Public Relations - works to promote and improve relations and understanding. Assists with publicity and news gathering. Usually chaired by chapter reporter
    c. Fund Raising - plans and helps raise funds. Chaired by chapter treasurer

d. Social - plans and coordinates all social activities

2. Special Committees

1. Are temporary committees designed to carry out a specific task or activity
2. Are generally dissolved upon satisfactory completion of assigned task or activity
3. May be either investigative or action type committee
   Examples:
   a. Investigate, report, and recommend to chapter locations, accommodations, and cost of forthcoming banquet
   b. Plan and obtain or provide entertainment for banquet

H. Committee Organization
Show: Transparency fig. 26

1. Should be broad representation of club membership for varied input
2. Members vary in number but no less than three members and chairperson
3. Should contain:
   a. Chairperson - usually appointed by president; organizes and coordinates committee work
   b. Ex officio member - usually vice-president; acts in an advisory capacity
   c. Recorder - usually appointed by chairperson, records proceedings, compiles data, prepares official reports
   d. Committee members - often appointed by the chair, provide input, make decisions through vote, work for common good

I. Club Activities

1. Should be based on the need of the student, school, community
2. Provide experiences and opportunities for members to grow

1. Educational

Refer: Leadership Handbook
1. Develop professional growth of membership
2. Stimulate interest in new methods, materials, and processes through:
   a. Field trips
   b. Guest speakers
   c. Films and special programs

2. Social

1. Provide enjoyment through entertainment activities
2. Develop social amenities through participation in planning, organizing, and conducting such activities as:
   - a. Open house and parent mixer
   - b. Employer - employee banquet and awards
   - c. Club social or recreational outing
   - d. Joint club social function (dance)

3. Service

1. Develop civic pride, attitude, responsibility
2. Derive satisfaction from helping others; especially those in need
3. Establish community understanding and promote public relations
4. Perform service to community
   - a. School/community beautification program
   - b. Build/repair school/community recreation equipment
   - c. Charity fund raising
   - d. Baskets for needy

4. Competitive

Refer: Texas VICA Competitive Activities Guide

1. Provides opportunity to excel
2. Promotes spirit of competition
3. Affords opportunity to meet and exchange ideas with members of other clubs through:
   - a. Local and district chapter competition
   - b. State skill olympics
   - c. U.S. skill olympics

J. Club Calendar

Show Transparency fig. 27

Refer: VICA Membership Yearbook

1. Provides a schedule of planned club activities
2. Provides a calendar of dates these activities occur
3. Serves to organize and notify
4. May be posted or given to each member
5. Should contain plan of events of all club activities such as:
   - a. Club meeting dates
   - b. Contest dates
   - c. National Vo. - Ed. week
   - d. Special activities dates

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Appoint committee to organize VICA club. Appoint chairperson! (Chairperson appoint recorder).
2. Discuss requirements (ingredients) of an active club.
3. Have students make list of committees they would be interested in serving on.
4. Form committee, and name chairperson, to draft local constitution.
5. Apply for charter with state director.
6. Nominate and elect chapter officers.
7. Hold officer installation ceremony.
8. Hold initiation ceremony for all members.
9. Appoint standing committees and chairpersons.
10. Plan calendar of events and club activities.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Essay Questions

1. List five ingredients for an active club.

Answer:
1. 100% active membership
2. Enthusiastic advisor
3. Qualified officers
4. Constitution and bylaws
5. Active committees
6. Energetic advisory committee
7. A calendar of activities

2. List four types of standing committees.

Answer:
1. Fiscal
2. Social
3. Fund Raising
4. Program
5. Contest

3. Four qualities of leadership sought in chapter officers are:

Answer:
1. Vigorous and enthusiastic
2. Impartial
3. Cooperative
4. Capable

4. List the officers in a local VICA chapter.

Answer:
1. President
2. Vice-President
3. Secretary
4. Treasurer
5. Reporter
6. Parliamentarian
7. Sergeant-at-arms

5. List four duties of club treasurer.

Answer:
1. Assists in making annual budget
2. Collects membership dues
3. Keeps accurate accounts of club finances
4. Pays club's bills as approved
5. Prepares financial statements and reports to membership

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT).

The success of the Vocational Industrial Clubs of America depends on the strength of its local chapters, for the local chapters are the backbone of the VICA organization. Conversely, the success of a local chapter depends on an active membership, and sound advice.

An active membership means dedicated and enthusiastic officers willing to accept the responsibility and carry out the duties of their office, and interested members willing to become involved by service on committees and participating in all chapter activities.

Remember, the success of a chapter is in direct relation to the ratio of its active members, and that what you get out of something depends on how much you are willing to put into it.

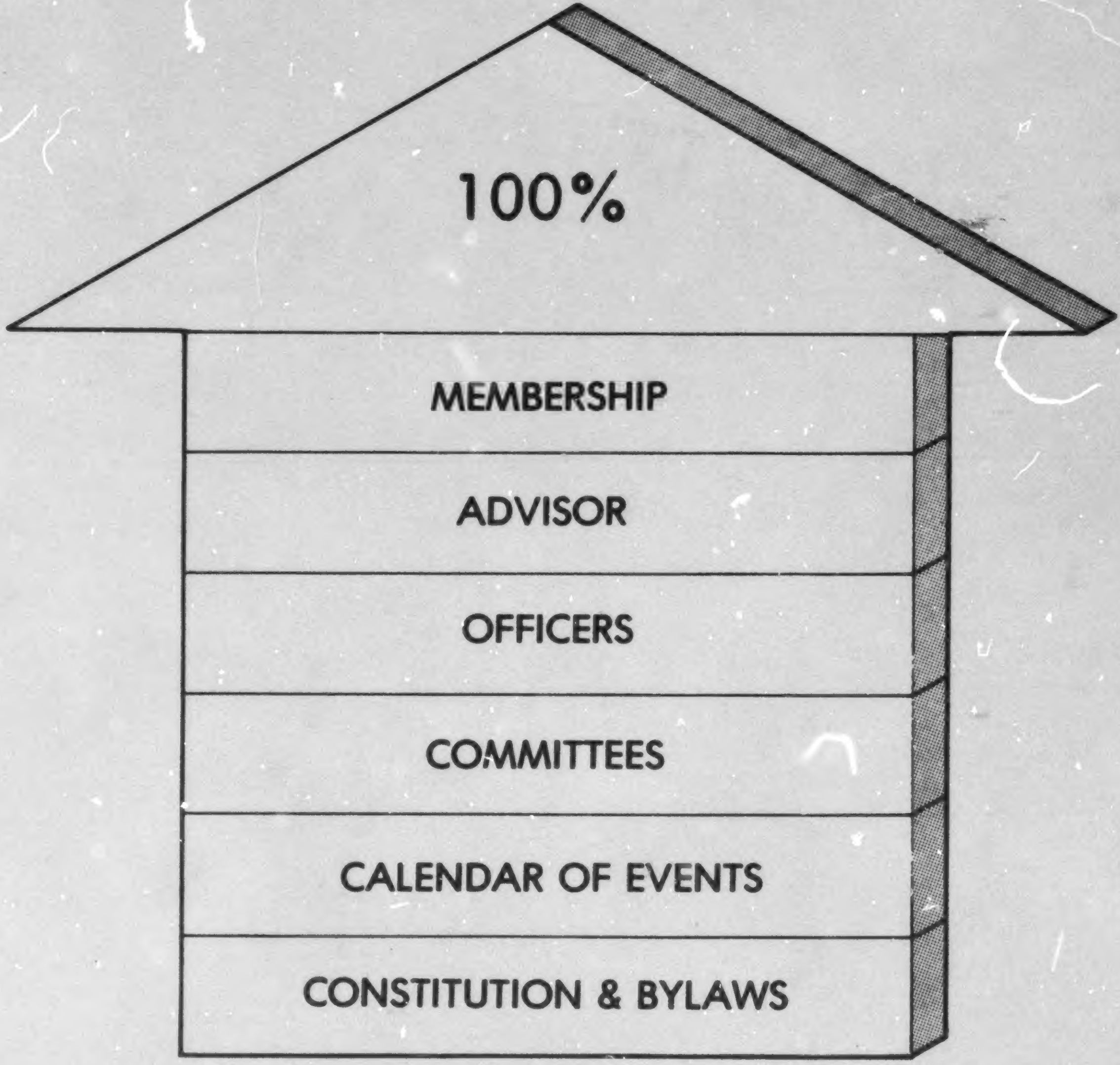
SUGGESTED READING FOR THE STUDENT:

Parliamentary Guide for Vocational Industrial Clubs of America

THE NEXT UNIT IS: Components and Symbols

LEADERSHIP DEVELOPMENT

VICA CLUB INGREDIENTS



100%

MEMBERSHIP

ADVISOR

OFFICERS

COMMITTEES

CALENDAR OF EVENTS

CONSTITUTION & BYLAWS

Fig. 23

LEADERSHIP DEVELOPMENT

OFFICER RESPONSIBILITY

LEADERSHIP

VIGOROUS

IMPARTIAL

COOPERATIVE

ABLE

LEADERSHIP DEVELOPMENT

QUALITIES OF A GOOD LEADER

INITIATIVE

RESPECT FOR OTHERS

ABILITY TO COMMUNICATE

STRENGTH OF CONVICTION

SPIRIT OF SERVICE

ENTHUSIASM & OPTIMISM

GOOD APPEARANCE

ACCEPTS RESPONSIBILITY

RESPECTED BY OTHERS

WELL INFORMED

OPEN MINDED

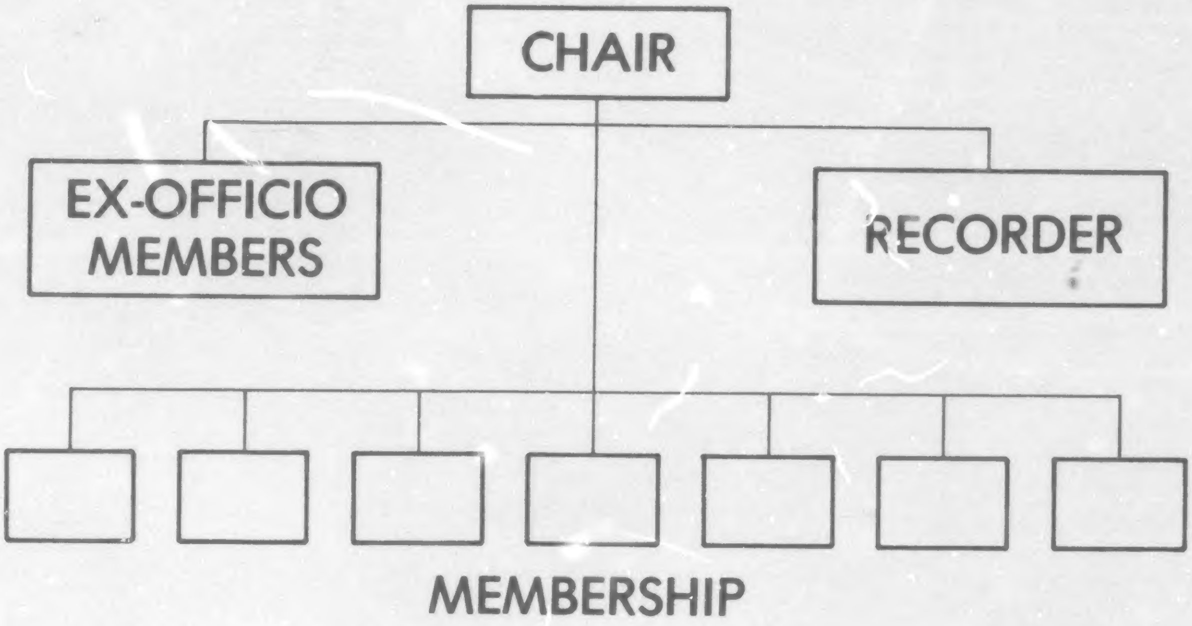
ABILITY TO WORK WITH OTHERS

BELIEF IN DEMOCRACY

Fig. 25

LEADERSHIP DEVELOPMENT

ORGANIZATION OF A COMMITTEE



CHAIR

EX-OFFICIO MEMBERS

RECORDER

MEMBERSHIP

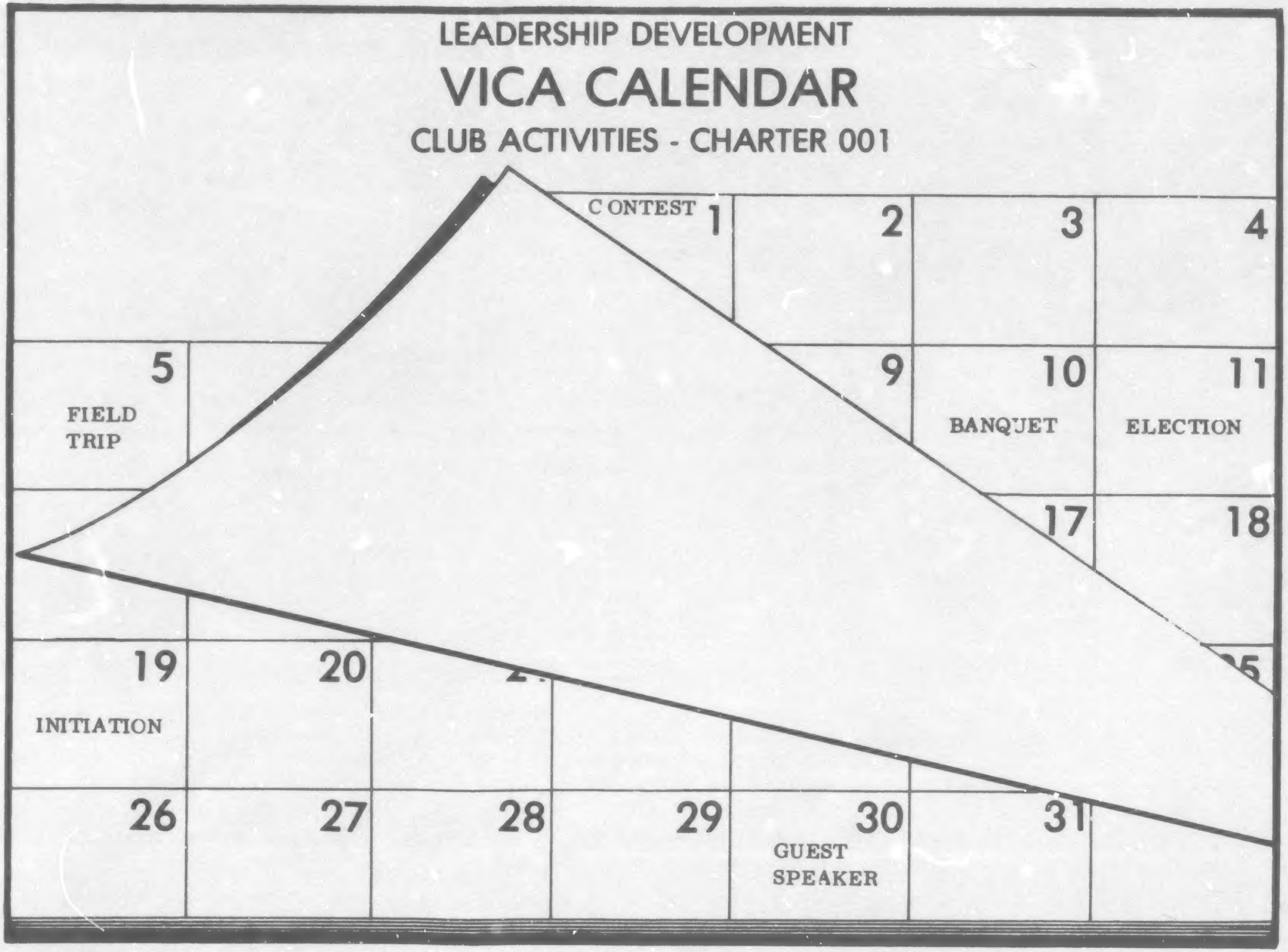

LEADERSHIP DEVELOPMENT
VICA CALENDAR
CLUB ACTIVITIES - CHARTER 001
CONTEST
1
2
3
4
5
FIELD TRIP
9
10
BANQUET
11
ELECTION
17
18
19
INITIATION
20
26
27
28
29
30
GUEST SPEAKER
31

Fig. 288

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT: Components and Symbols

AIM: Upon successful completion of the lesson, the student will be able to recognize electronic components and symbols and associate each component with its symbol.

TEACHING AIDS: Chalkboard, overhead projector, Transparency 19500, fig. 28

MATERIALS:
Assignment sheet - components and symbols
Assignment sheet - letter symbols
Experiment # 2 - component symbols and abbreviations
Test sheet - components and symbols

TOOLS AND EQUIPMENT: Student lab station, component set

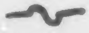
REFENCES:
Fowler, Electricity: Principles and Applications
Grob, Basic Electronics
De Vito, Introduction to Electricity and Electronics

PREREQUISITE EXPERIENCE OF THE LEARNER: Shop safety awareness

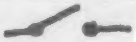
I. PREPARATION (OF THE LEARNER - MOTIVATION)

You have listened to a transistor radio or watched television but have you seen the components inside? When connected properly, these make the system work. Can you tell which components are connected together? The schematic diagram is the "road map" used by the technician and engineer to find his or her way through the circuits. In this lesson you will learn to read schematic symbols in all the circuit diagrams we will use throughout this course and in your career in electronics.

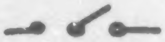
II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Fuse	1. An electrical safety device to protect the circuit
Show Transparency fig. 28	2. Rating: amperes
	3. Schematic symbol: 
	4. Letter symbol: F
B. Switches	1. Used to control current flow in a circuit
	2. Rating: voltage and current

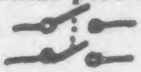
3. Types and schematic symbols:
   a. Single pole single throw (SPST):



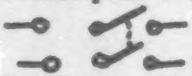
   b. Single pole double throw (SPDT):



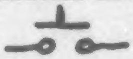
   c. Double pole single throw (DPST):



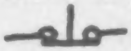
   d. Double pole double throw (DPDT):



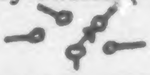
   e. Pushbutton normally open (PBNO):



   f. Pushbutton normally closed (PBNC):



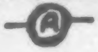
   g. Rotary switch (--pole --position):



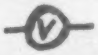
4. Letter symbol: S

C. Meters

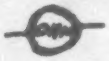
1. Used to measure quantities in circuits
2. Rating: maximum full-scale values
3. Types and schematic symbols:
   a. Ammeter: measures current:



   b. Voltmeter: measures voltage:

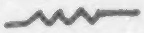
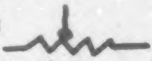
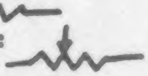
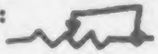


   c. Ohmmeter: measures resistance:



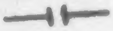
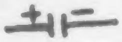
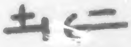
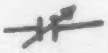
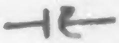
4. Letter symbol: M

D. Resistors

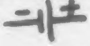
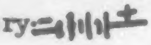
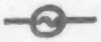
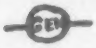
1. Component which opposes current flow
2. Rating: ohms (Greek letter Omega) Ω
3. Types and schematic symbols:
   a. Fixed: 
   b. Tapped: 
   c. Potentiometer: 
   d. Rheostat: 

4. Letter symbol: R

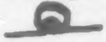
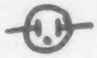
E. Capacitors

1. Stores an electrical charge
2. Rating: farads (F) and voltage (E)
3. Types and schematic symbols:
   a. Fixed: 
   b. Electrolytic:  or 
   c. Variable:  or 
4. Letter symbol: C

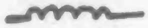
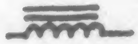
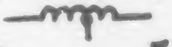
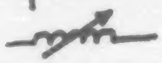
F. Voltage source

1. Pressure which causes current flow
2. Rating: volts (V)
3. Types and schematic symbols:
   a. Cell: 
   b. Battery: 
   c. Generator:  or 
4. Letter symbol: B

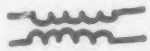
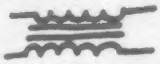
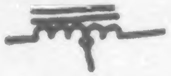
G. Lamps

1. Provide light or an indicator
2. Rating: voltage and current
3. Types and schematic symbols:
   a. Incandescent: 
   b. Neon: 
4. Letter symbol: LP

H. Inductor (coils)

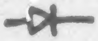
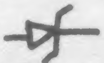
1. Used to produce a magnetic field
2. Rating: henry (H)
3. Types and schematic symbols:
   a. Fixed (air core): 
   b. Fixed (iron core) (choke): 
   c. Tapped: 
   d. Adjustable: 
4. Letter symbol: L

I. Transformers

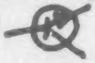
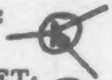
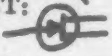
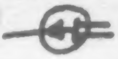
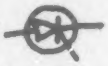
1. Transfer or transform power
2. Rating: primary and secondary voltage and current
3. Types and schematic symbols:
   a. Air core: 
   b. Iron core: 
   c. Autotransformer: 

4. Letter symbol: T

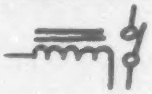
J. **Diodes**

1. Allows current flow in one direction only
2. Rating: forward current and P.I.V.
3. Types and schematic symbols:
   a. Typical diode: 
   b. Zener diode: 

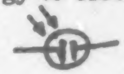
K. **Transistors**

1. Semiconductor device used to control current
2. Types and schematic symbols:
   a. NPN bipolar: 
   b. PNP bipolar: 
   c. N channel FET: 
   d. P channel FET: 
   e. SCR: 
3. Letter symbol: Q

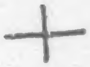
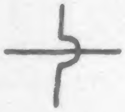
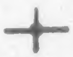
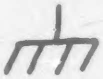
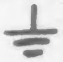
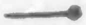
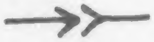
L. **Relay**

1. Remote control switch
2. Ratings: switch type and maximum current
3. Schematic symbol: 
4. Letter symbol: K

M. **Solar cell**

1. Converts light energy to electrical energy
2. Schematic symbol: 
3. Letter symbol: SC

N. **Connections and Conductors**

1. Interconnect components on schematics and circuits
2. Schematic symbols:
   a. Conductor:
   b. No connection:  or 
   c. Connection: 
   d. Chassis connection: 
   e. Ground connection: 
   f. Terminal:  or 

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment sheet - components and symbols
2. Assignment sheet - letter symbols
3. Experiment # 2 - component symbols and abbreviations
4. Check each student's work for completeness and accuracy

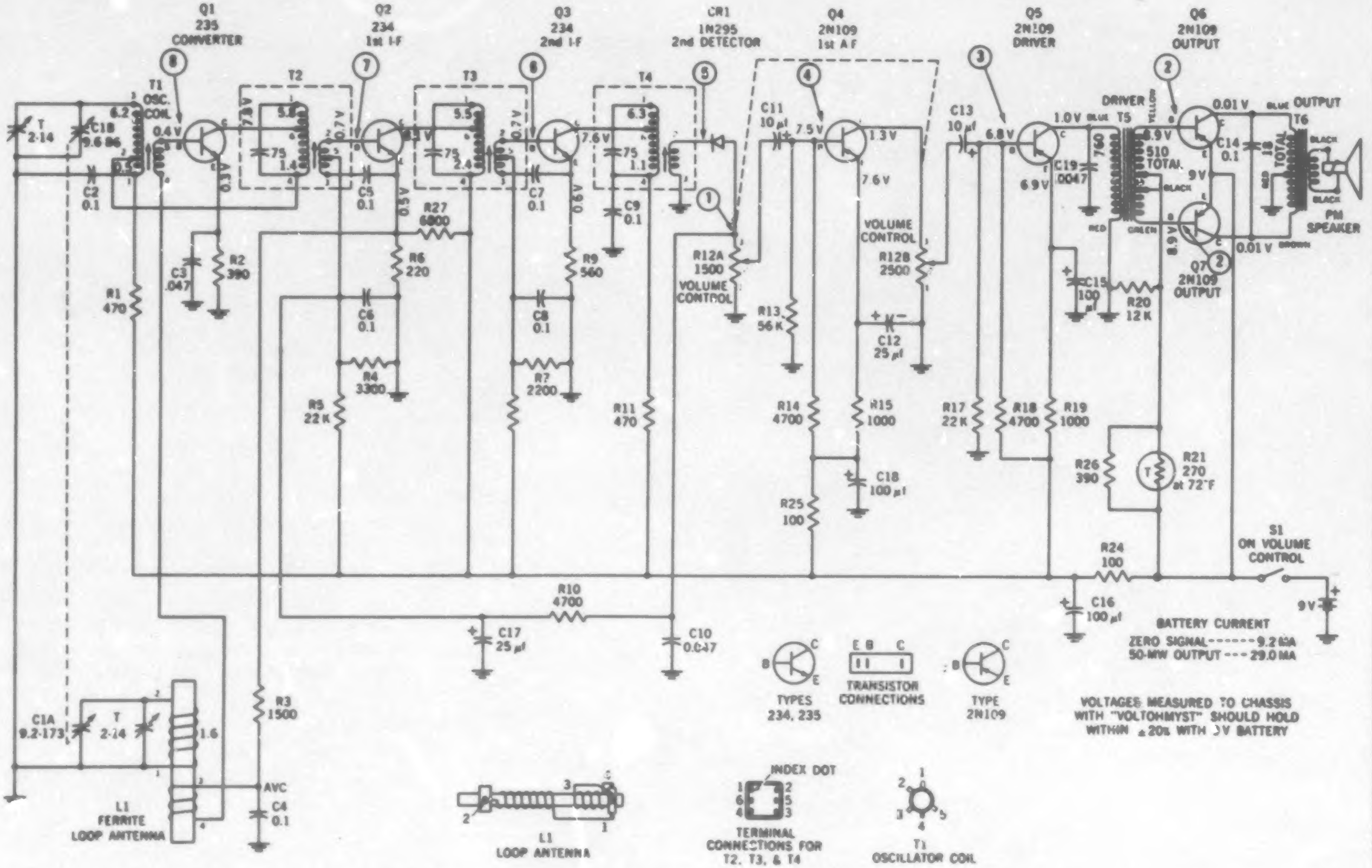
IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions.
2. Test sheet - components and symbols
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss the test and answer student questions.
2. Review major topics of the presentation.

THE NEXT LESSON IS: Tools


Q1
235
CONVERTER
Q2
234
1st I-F
Q3
234
2nd I-F
CR1
1N295
2nd DETECTOR
Q4
2N109
1st A F
Q5
2N109
DRIVER
Q6
2N109
OUTPUT
T1
OSC.
COIL
T2
T3
T4
DRIVER T5
OUTPUT T6
0.4 V
0.7 V
7.6 V
7.5 V
1.3 V
7.6 V
6.8 V
6.9 V
1.0 V
8.9 V
9 V
0.01 V
C1B
9.6-86
C1A
9.2-173
C2
0.1
C3
.047
C4
0.1
C5
0.1
C6
0.1
C7
0.1
C8
0.1
C9
0.1
C10
0.047
C11
10 μf
C12
25 μf
C13
10 μf
C14
0.1
C15
100 μf
C16
100 μf
C17
25 μf
C18
100 μf
C19
.0047
R1
470
R2
390
R3
1500
R4
3300
R5
22 K
R6
220
R7
2200
R9
560
R10
4700
R11
470
R12A
1500
VOLUME
CONTROL
R12B
2500
VOLUME
CONTROL
R13
56 K
R14
4700
R15
1000
R17
22 K
R18
4700
R19
1000
R20
12 K
R21
270
at 72°F
R24
100
R25
100
R26
390
R27
6800
510
TOTAL
760
18
TOTAL
Q7
2N109
OUTPUT
PM
SPEAKER
S1
ON VOLUME
CONTROL
9 V
BATTERY CURRENT
ZERO SIGNAL - - - - - - 9.2 MA
50-MW OUTPUT - - - 29.0 MA
TYPES
234, 235
TRANSISTOR
CONNECTIONS
TYPE
2N109
VOLTAGES MEASURED TO CHASSIS
WITH "VOLTOHMYST" SHOULD HOLD
WITHIN ±20% WITH 9V BATTERY
L1
FERRITE
LOOP ANTENNA
AVC
L1
LOOP ANTENNA
INDEX DOT
TERMINAL
CONNECTIONS FOR
T2, T3, & T4
T1
OSCILLATOR COIL
BLUE
YELLOW
BLACK
RED
GREEN
BROWN

Transistor radio receiver, using a 9-volt battery as positive voltage source. (*Courtesy of Radio Corp. of America.*)

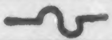
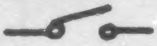
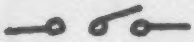
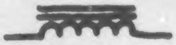
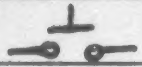
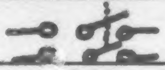
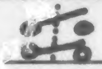
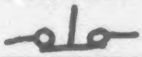
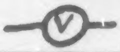
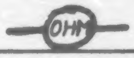
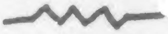
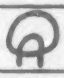
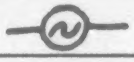
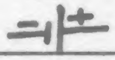
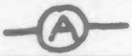
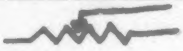
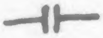
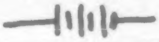
BEST COPY AVAILABLE

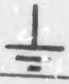
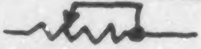
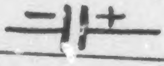
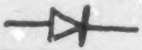
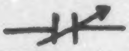
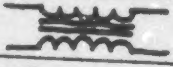
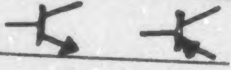
COMPONENTS AND SYMBOLS

II-A-1a(AS)
Key

Name ____________________ Date ____________________

DIRECTIONS: Each student will complete this assignment sheet on an individual basis. Fill in the blanks with the proper component name, graphic symbol or letter symbol. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

	COMPONENT NAME	GRAPHIC SYMBOL	LETTER SYMBOL
1.	FUSE		F
2.	Switch Single Post Single Throw		S
3.	SWITCH, SINGLE POLE DOUBLE THROW		S
4.	COIL, IRON CORE		L
5.	Switch Normally open push button		S
6.	SWITCH, DOUBLE POLE DOUBLE THROW		S
7.	SWITCH, DOUBLE POLE SINGLE THROW		S
8.	Switch, Normally closed push button		S
9.	VOLTMETER		M
10.	Ohmmeter		M
11.	RESISTOR, FIXED		R
12.	Incandescent lamp		LP
13.	A. C. GENERATOR		GEN
14.	cell		B
15.	ammeter		M
16.	POTENTIOMETER		R
17.	capacitor		C
18.	BATTERY		B

19. Ground		GND
20. RHEOSTAT		R
21. Electrolytic capacitor		C
22. DIODE		D
23. VARIABLE CAPACITOR		C
24. IRON CORE TRANSFORMER		T
25. TRANSISTORS NPN & PNP		Q

LETTER SYMBOLS

Name ______________________________ Date ________________________

		1 I	N	D	U	2 C	T	O	R						
						A									
				3 F		P									
				U		A									
				S		C									
			4 R	E	S	I	S	T	O	R					
			E			T							5 D		
			L			O							I		
			A		6 T	R	A	N	7 S	I	S	T	O	R	
			Y		R				W				D		
					A				I				E		
					N		8 M	E	T	E	R				
					S				C						
					F				H						
					O										
					R										
			9 L	A	M	P									
					E										
10 B	A	T	T	E	R	Y									

Across Clues:

1. L
4. R
6. Q
8. M
9. LP
10. B

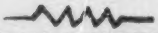
Down Clues:

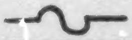
2. C
3. F
4. K
5. D
6. T
7. S

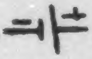
TEST

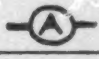
Name ____________ Date ____________

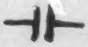
DIRECTIONS: Read each statement carefully. Place the proper symbol or word which best completes the statement in the space provided. Be sure to check your answers.

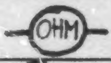
 1. The graphic symbol for a fixed resistor is ____.

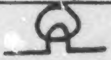
 2. The graphic symbol for a fuse is ____.

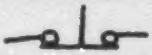
cell 3. The component name for this symbol,  is ____.

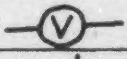
 4. The graphic symbol for an ammeter is ____.

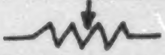
capacitor 5. The component name for this symbol,  is ____.

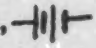
 6. The graphic symbol for an ohmmeter is ____.

 7. The graphic symbol for a lamp is ____.

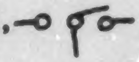
 8. The graphic symbol for a switch, PBNC is ____.

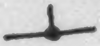
 9. The graphic symbol for a voltmeter is ____.

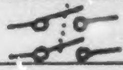
 10. The graphic symbol for a potentiometer is ____.

B 11. The letter symbol for this component,  is ____.

L 12. The letter symbol for an air core coil is ____.

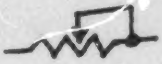
Switch, Single Pole, Double Throw 13. The component name for this symbol,  is ____.

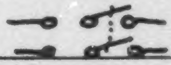
connection 14. The component name for this symbol,  is ____.

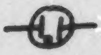
 15. The graphic symbol for a switch, DPST is ____.

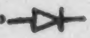
Q 16. The letter symbol for a transistor is ____.

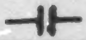
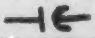
R 17. The letter symbol for a potentiometer is ____.

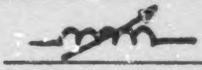
rheostat 18. The component name for this symbol,  is ____.

 19. The graphic symbol for a switch, DPDT is ____.

neon lamp 20. The component name for this symbol,  is _____.

D or CR 21. The letter symbol for this component,  is ______.

 or  22. The graphic symbol for a fixed capacitor is _______.

 23. The graphic symbol for an adjustable coil is _____.

B 24. The letter symbol for a cell is _____.

D or CR 25. The letter symbol for a diode is _______.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-B-1(I)

SUBJECT:	Meter Measurements
AIM:	Upon successful completion of the lesson, the student will be able to properly and safely make measurements of voltage, current and resistance using typical volt-ohm-milliammeters.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, figs. 29-32
MATERIALS:	Information Sheet - (Teacher prepared) Assignment Sheet - Meter Measurements Task Sheet - Using the VOM Experiment #3 - Introduction to the Electronic VOM Test Sheet - Meter Measurements
TOOLS AND EQUIPMENT:	Student lab station, component set, VOM
REFERENCES:	De Vito, Introduction to Electricity and Electronics Fowler, Electricity - Principles and Applications Gilmore, Instruments and Measurements Instruction manuals, student lab stations
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Electricity cannot be seen. We can feel a sensation from an electric current flowing through our body, but we cannot measure the amount by touching. In electronics, you will rely on various measuring instruments to detect and measure the presence of electricity. Meters are the most commonly used instruments for this purpose. In this lesson, you will learn how to use the types of meters most commonly found in the electronics industry to measure voltage, current and resistance.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Meter function Show Transparency fig. 29	1. Voltmeter a. Used to measure potential difference or voltage in an electric circuit b. Connect "across" or in parallel with voltage to be measured c. Observe polarity (+ to + and - to -)

Show Transparency fig. 30

2. Ammeter
    a. Used to measure current flow through electric circuit
    b. Circuit must be opened and the meter inserted in series
    c. Observe polarity (meter + towards source +)

Show Transparency fig. 31

3. Ohmmeter
    a. Used to measure the component or circuit resistance to electric current flow
    b. For safety, all power must be removed from circuit before measuring resistance
    c. Adjust zero setting
    d. Connect test leads, polarity is not important on most measurements

B. Meter scale reading

Show Transparency fig. 32

1. Observe full scale value
2. Determine value of major divisions
3. Determine value of minor divisions
4. Using the major and minor division values, interpret the value indicated by the needle or pointer

C. Multimeter operation

1. Multimeters are instruments used to measure several electrical quantities
2. Controls
    a. Function switch - sets the meter function to voltmeter, ammeter or ohmmeter
    b. Range control - sets the full scale value for the meter movement
    c. Zero adjust - sets the pointer to zero when using the ohmmeter function
3. Functions
    a. Voltmeter - set function control to voltage and connect in parallel across the voltage source
    b. Ammeter - set function control to current and connect in series with current source
    c. Ohmmeter - set function control to resistance, set zero adjust and connect across unknown resistance

D. Electronic VOM's

1. Field effect transistor (FET) meter
    a. A solid-state or electronic VOM
    b. Has little effect on the circuit being measured
2. Vacuum tube volt meter (VTVM)

a. Electronic meter using vacuum tubes
b. Characteristics similar to the FET meter
c. Most are being replaced with the transistorized meters

3. Digital readout meters
a. Electronic multimeter with number display of values
b. Easier to read than analog display
c. Usually more accurate than analog meters

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Measurements
2. Task Sheet - Using the VOM
3. Experiment # 3 - Introduction to the Electronic VOM
4. Check each student's work for completeness and accuracy
5. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Have students demonstrate meter setup and operation
3. Test Sheet - Measurements
4. 70% correct is required for satisfactory completion of the lesson

---

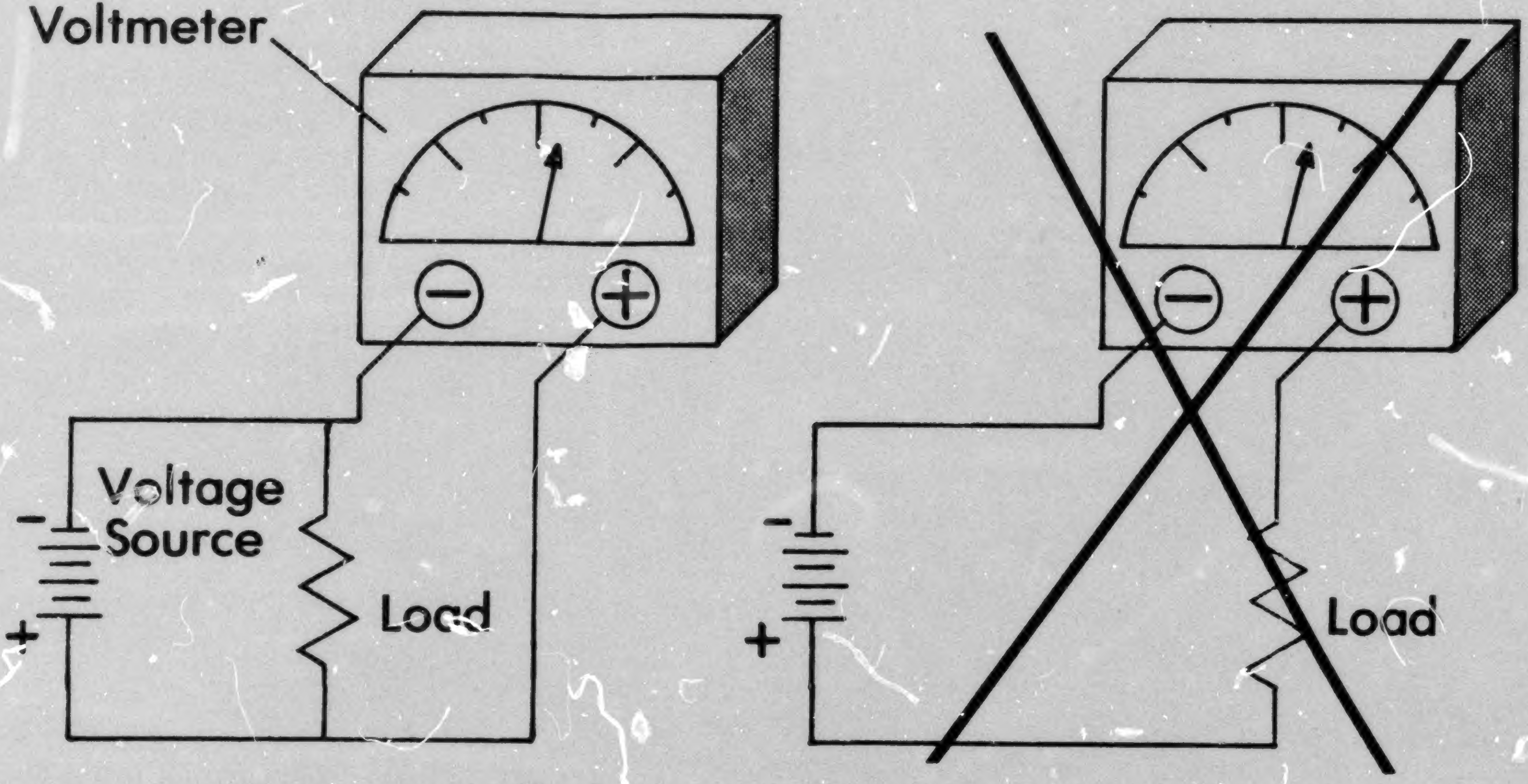
V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the presentation

THE NEXT LESSON IS: Tools

DC VOLTMETER ATTACHMENT

CORRECT **WRONG**



Voltmeter
−
+
Voltage Source
Load
−
+
Load

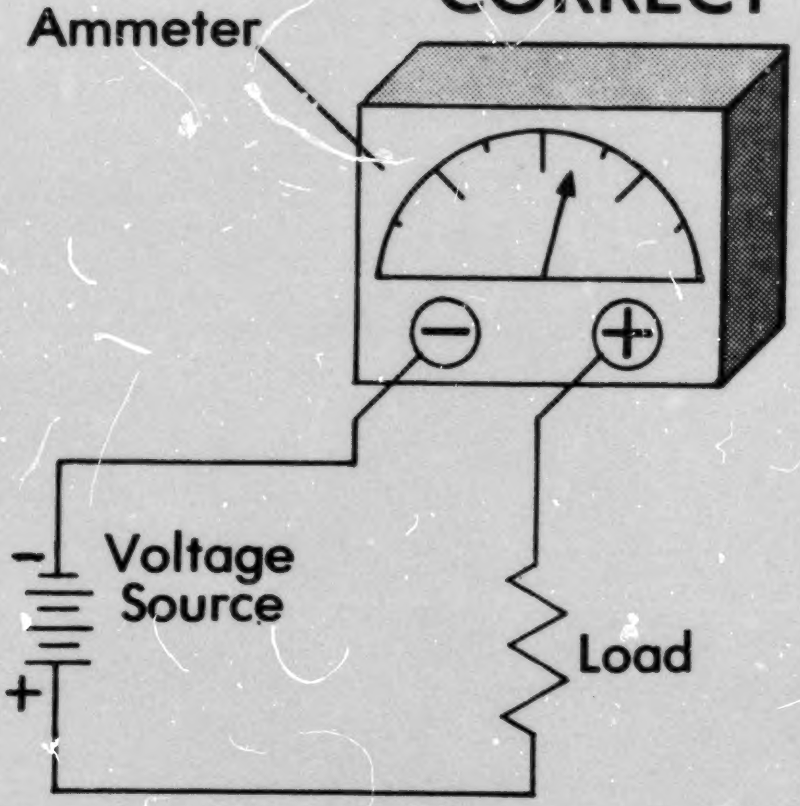
ALWAYS in Parallel

NEVER in Series

Fig. 29

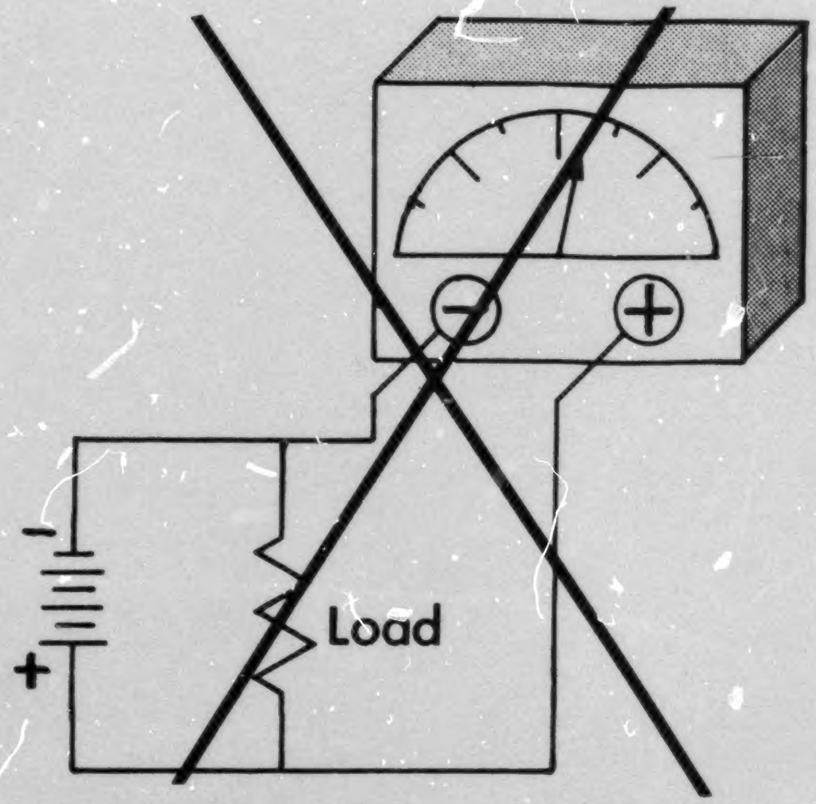
AMMETER ATTACHMENT

CORRECT


Ammeter
−
+
−
Voltage Source
+
Load

ALWAYS in Series

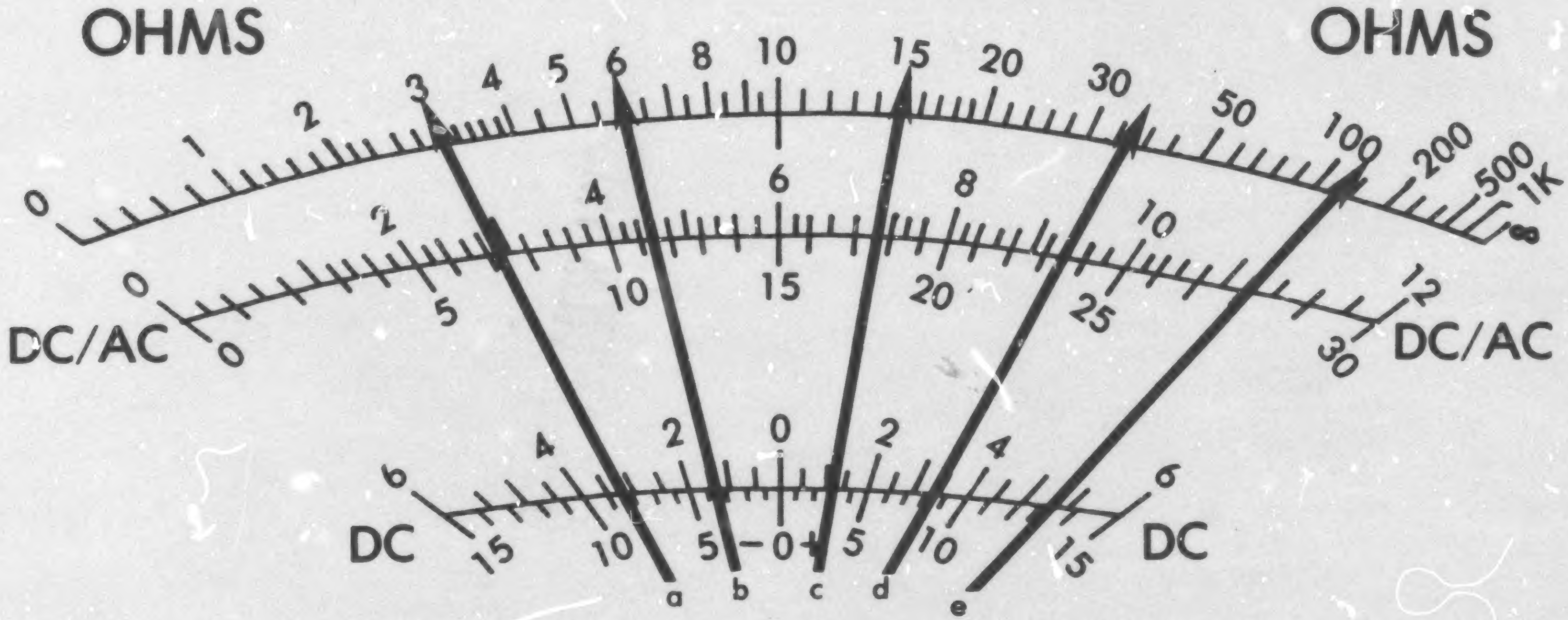
WRONG



NEVER in Parallel

Fig. 30

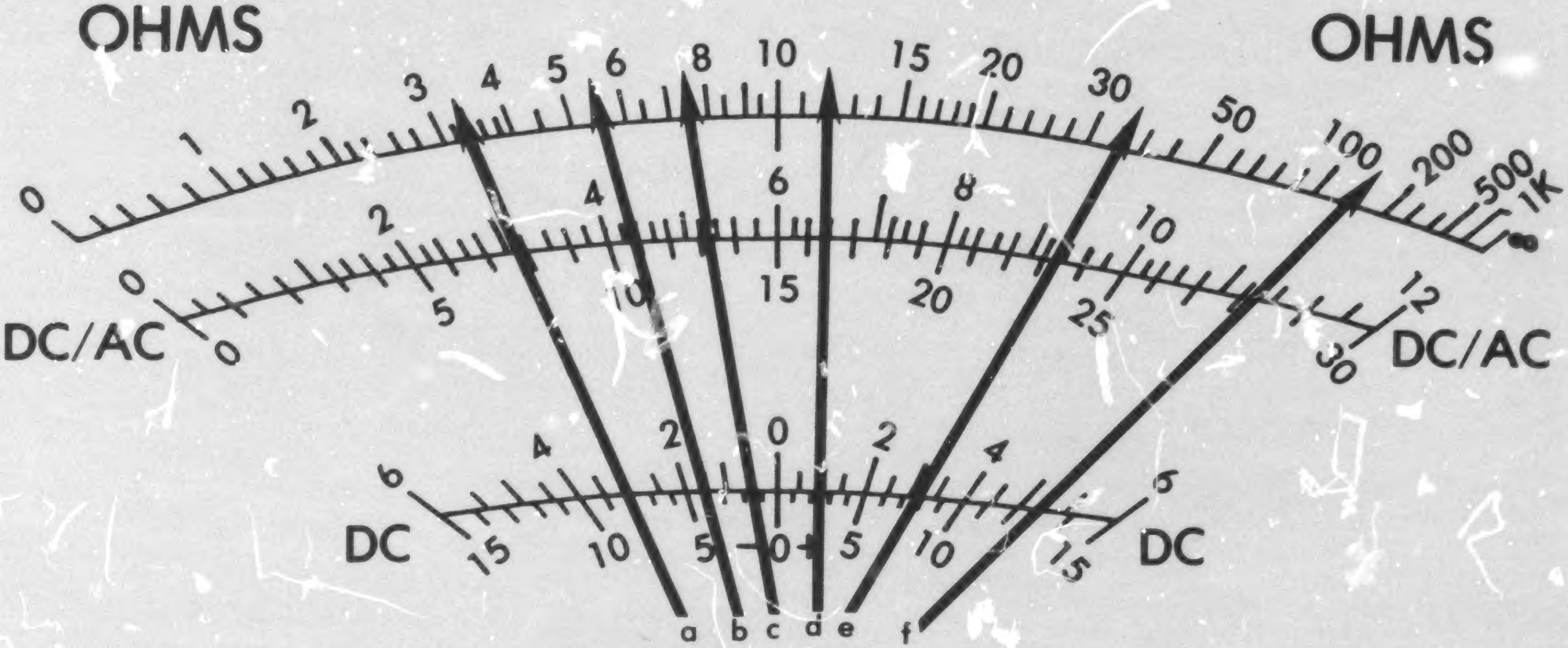
METER READING


OHMS
OHMS
0 1 2 3 4 5 6 8 10 15 20 30 50 100 200 500 1K ∞
0 2 4 6 8 10 12
0 5 10 15 20 25 30
DC/AC
DC/AC
6 4 2 0 2 4 6
15 10 5 − 0 + 5 10 15
DC
DC
a
b
c
d
e

DC - 30V RANGE

Fig. 31

METER READING


OHMS
OHMS
0 1 2 3 4 5 6 8 10 15 20 30 50 100 200 500 1K ∞
0 2 4 6 8 10 12
0 5 10 15 20 25 30
DC/AC
DC/AC
6 4 2 0 2 4 6
15 10 5 −0+ 5 10 15
DC
DC
a b c d e f

OHM SCALE = R x 1

Fig. 32

METER MEASUREMENTS

II-B-1(AS)

Name ______________________________ Date ___________________________

DIRECTIONS: This assignment sheet is to be completed on an individual basis. Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Check all your answers to be sure they are correct. If you have any questions, ask your instructor.

parallel 1. A voltmeter is always connected in ____with the circuit being measured.

series 2. An ammeter is always connected in ____with the circuit being measured.

range 3. Always set a meter to the highest ____setting before measuring an unknown voltage or current.

polarity 4. Always be sure to connect a meter in the circuit with the correct ____so the meter will not read backwards and be damaged.

touch 5. For your safety, care must be taken not to ____more than one point in a circuit with a meter probe.

voltage 6. An ammeter can be ruined instantly if connected across a/an ____.

range 7. The ____switch on a VOM sets the maximum value which can be measured at that setting.

function 8. On a multimeter, the ____switch determines what is to be measured.

VTVM 9. A/an ____requires several minutes of warm-up time before it can be used for measurements.

off 10. For your safety, always connect meters to circuits with the power turned ____if at all possible.

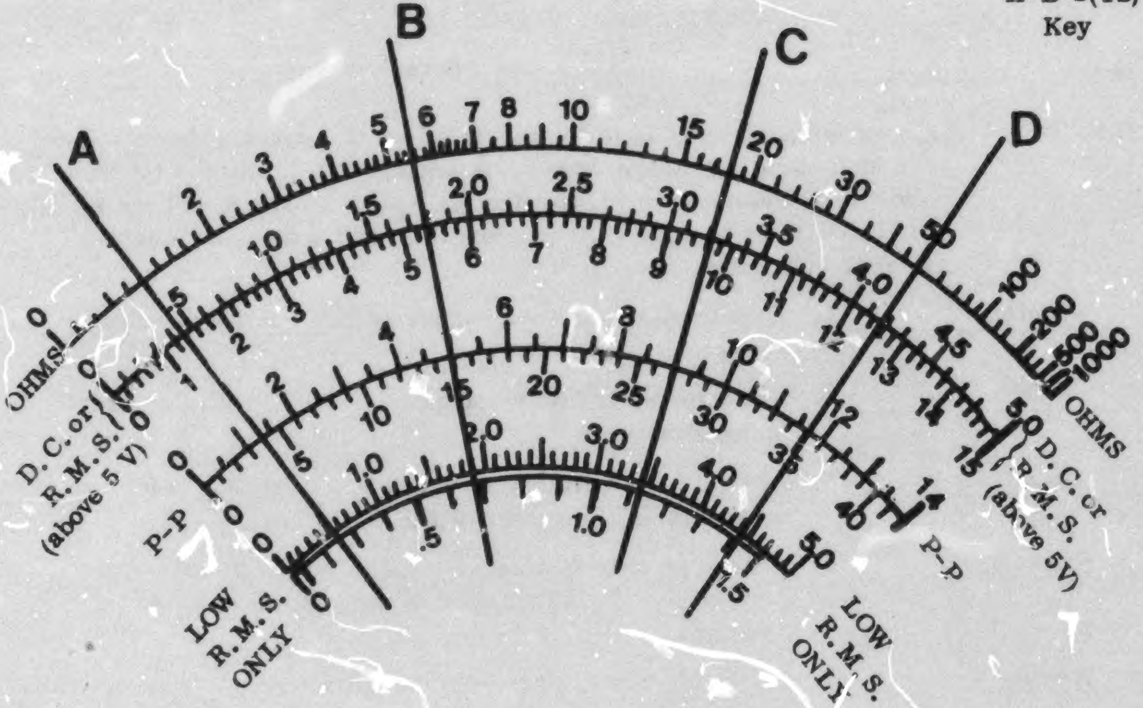
right 11. The most accurate voltage readings are obtained at the ____portion of the scale.

left 12. The most accurate resistance readings are obtained at the ____portion of the scale.

adjust 13. The ____control must be set before making a resistance measurement to insure a more accurate reading.

straight 14. To insure a greater accuracy, always read a meter when looking ____at its face.

carefully 15. Always handle meters _____, they are delicate and expensive instruments.


A
B
C
D
OHMS
D.C. or R.M.S. (above 5 V)
P-P
LOW R.M.S. ONLY
OHMS
D.C. or R.M.S. (above 5V)
P-P
LOW R.M.S. ONLY
0
1
2
3
4
5
6
7
8
10
15
20
30
50
100
200
500
1000
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
9
11
12
13
14
15
25
35
40

Directions: Complete the chart using the meter scale and pointers in figure 1. If you have any questions, ask your instructor.

Function	Range	Pointer A	Pointer B	Pointer C	Pointer D
DCV	15	1,4 VDC	5.4 VDC	9,6 VDC	12,5 VDC
ACV	500	47 VAC	180 VAC	320 VAC	415 VAC
Ohms	x100	100 Ω	550 Ω	1,8K Ω	5K Ω
DCV	5	,47 VDC	1,8 VDC	3,2 VDC	4,15 VDC
ACV	1,5	,25 VAC	.69 VAC	1,1 VAC	1,41 VDC
Ohms	x10K	10K Ω	55K Ω	180K Ω	500K Ω
DCV	50	4,8 VDC	18 VDC	32 VDC	41,8 VDC
ACV	150	14 VAC	54 VAC	96 VAC	125 VAC
Ohms	x10	10 Ω	55 Ω	180 Ω	500 Ω
DCV	500	47 VDC	180 VDC	320 VDC	419 VDC
ACV	1500	140 VAC	540 VAC	960 VAC	1,25 K VAC
Ohms	x100K	100K Ω	550K Ω	1.8 M Ω	5 M Ω
DCV	150	14 VDC	54 VDC	96 VDC	125 VDC
ACV	5	.5 VAC	1,8 VAC	3,4 VAC	4.4 VAC
Ohms	x1M	1M Ω	5,5M Ω	18M Ω	50M Ω
DCV	1,5	,14 VDC	.54 VDC	,96 VDC	1,25 VDC
ACV	50	4,8 VAC	18 VAC	32 VAC	41.8 VAC
Ohms	x1K	1K Ω	5,5K Ω	18 K Ω	50 K Ω

II-B-1(T)

TEST
ON
METER MEASUREMENTS

Name ______________________________ Date __________________________

DIRECTIONS: Read each statement carefully. Place the word or words which best completes the statement in the space provided. Be sure to check your answers.

___parallel___ 1. A voltmeter is always connected in ________ with the circuit being measured.

___series___ 2. An ammeter is always connected in _______ with the circuit being measured.

___range___ 3. Always set a meter to the highest ______ setting before measuring an unknown voltage or current.

___polarity___ 4. Always be sure to connect a meter in the circuit with the correct _____ so the meter will not be damaged.

___VTVM electronic___ 5. A/an ____ meter requires time to warm-up before using to make measurements.

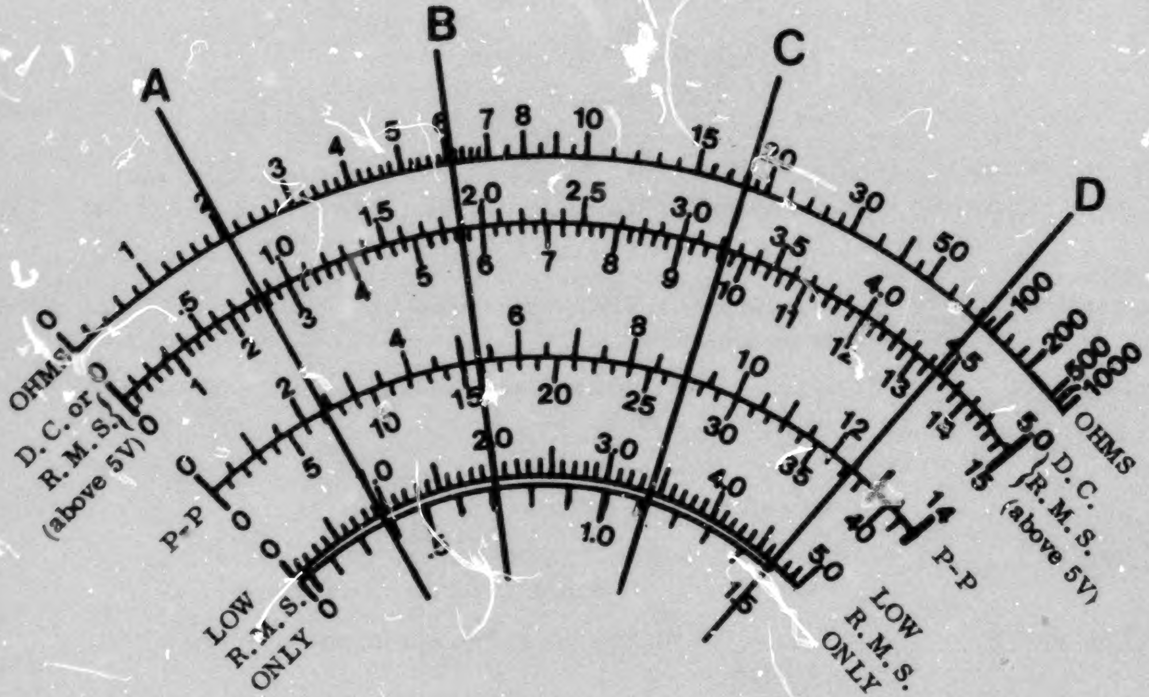
___off___ 6. For your safety, always connect meters to circuits with the power turned _____ whenever possible.

___touch___ 7. Care must be taken not to ______ more than one point in a circuit with a meter probe.

___adjust___ 8. The ______ must be set on an ohmmeter before making any measurements to insure a more accurate reading.

___ohm___ 9. Never connect a/an ______ meter to a circuit having any voltage.

___voltage___ 10. An ammeter can be ruined instantly if connected across a/an _____.


A
B
C
D
OHMS
D.C. or R.M.S. (above 5V)
P-P
LOW R.M.S. ONLY
D.C. R.M.S. (above 5V)
P-P
LOW R.M.S. ONLY
OHMS

Directions: Complete the chart using the meter scale and pointers in figure 1. Be sure to check your answers.

	Function	Range	Pointer	Reading
11.	ACV	1.5	A	.39V
12.	DCV	500	B	190V
13.	Ohms	x10K	C	180KΩ
14.	ACV	50	D	44.2V
15.	DCV	15	A	2.6V
16.	Ohms	x10	B	60 Ω
17.	ACV	150	C	96V
18.	DCV	50	D	44.2V
19.	Ohms	x1K	A	2KΩ
20.	ACV	5	B	2V
21.	DCV	15	C	9.6V
22.	Ohms	x100K	D	8MΩ
23.	ACV	1500	A	260V
24.	DCV	5	B	1.9V
25.	DCV	5	B	1.9V

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

II-C-1(I)

SUBJECT: Hand and Power Tools

AIM: Upon successful completion of the lesson, the student will be able to identify, properly care for and safely use the basic tools used in the electronics industry.

TEACHING AIDS: Chalkboard, overhead projector, Transparency 19500, fig. 33

MATERIALS:
Information Sheet - Safety Rules for Tools
Assignment Sheet - Tools
Assignment Sheet - Tool Puzzle
Test Sheet - Tools

TOOLS AND EQUIPMENT: All tools available for student checkout

REFERENCE: Mangieri, A.A., "Tools for Electronics Experimenters", Popular Electronics

PREREQUISITE EXPERIENCE OF THE LEARNER: Shop safety

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Most of the tools you will need in this course are furnished by the school. Tools are expensive to purchase so it is necessary to use them properly and to take good care of them. In this lesson you will also learn to use tools safely to prevent accidental injury to yourself or someone working near you. Each tool is made for a specific purpose, you will learn the purpose, the proper use, and the care they need to be effective and last a long time. Some jobs require you to furnish your own tools. This lesson will give you a good start towards selecting, using and caring for your or your employer's tools.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Hand tools	1. Eye protection a. Safety glasses b. Safety goggles 2. Screwdrivers a. Standard tip 1. Tip sizes 2. Proper fit 3. Proper shape

- b. Phillips tip
  - 1. Sizes by number
  - 2. Tip shape (flat or blunt)
- c. Reed and Prince tip
  - 1. Tip shape
  - 2. Uses
- d. Clutch tip
  - 1. Tip shape
  - 2. Uses
- e. Screwholding types
  - 1. Styles
  - 2. Uses

3. Screwdriver misuses
   - a. Chisel or pry bar
   - b. Pliers on shank
   - c. Worn tip (show correct shape)
   - d. Use proper size
   - e. Hold screwdriver in a straight line with screw
4. Pliers
   - a. Diagonal cutting
     - 1. Sizes
     - 2. Misuses
       - (a) Not wearing safety glasses
       - (b) Cutting materials that are too hard
       - (c) Cutting materials that are too large
   - b. Slip joint and "Channel Lock"
     - 1. Styles
     - 2. Sizes
     - 3. Misuses
       - (a) Use proper size and type for job
       - (b) Do not use on hex shape nuts
   - c. Long nose
     - 1. Sizes
     - 2. Misuses
       - (a) Do not hold pieces tightly at extreme tip
       - (b) Use proper size
       - (c) Not for heavy work
   - d. Locking types
     - 1. "Vise Grip"
     - 2. Surgical hemostat
     - 3. Misuses
       - (a) Use proper sizes
       - (b) Can damage small parts

- e. Fuse puller
  - 1. Styles
  - 2. Uses
- f. Wire terminal
  - 1. Styles
  - 2. Uses
- g. Wire stripper
  - 1. Styles
  - 2. Uses
- h. Shears
  - 1. Styles
  - 2. Uses

5. Wrenches
   - a. Combination (open end/boxed end)
     - 1. Sizes
     - 2. Uses
   - b. Adjustable "Crescent"
     - 1. Sizes
     - 2. Uses
     - 3. Misuses
       - (a) Wrong size
       - (b) Should be pulled not pushed
       - (c) Adjustable jaw should be next to you (this puts strain on heavier jaw)
   - c. Nut drivers
     - 1. Sizes
     - 2. Uses
   - d. Socket set
     - 1. Sizes
     - 2. Uses
   - e. Allen and spline
     - 1. Sizes
     - 2. Uses
6. Chisels and punches
   - a. Chisels
     - 1. Sizes
     - 2. Caution
       - (a) Wear eye protection
       - (b) Cut away from you
       - (c) Don't let head become mushroomed
   - b. Center punch
     - 1. Types
     - 2. Uses
   - c. Chassis punch
     - 1. Sizes
     - 2. Uses

7. Miscellaneous
   - a. Files
     - 1. Shape
     - 2. Parts (teeth and tang)
     - 3. Uses
   - b. Hacksaw
     - 1. Uses
     - 2. Blades
       - (a) Teeth per inch (18 most suitable)
       - (b) Teeth pointed forward
   - c. Vise
     - 1. Types
     - 2. Uses
   - d. Soldering tools
     - 1. Covered in lesson on soldering
     - 2. Preview soldering safety
   - e. Twist drills
     - 1. Sizes
     - 2. Care
   - f. Ruler - square
     - 1. Uses
     - 2. Care

B. Power tools

1. Drill press
   - a. Uses
   - b. Set up
   - c. Safety rules (posted on drill press)
2. Hand drill
   - a. Types
   - b. Uses
3. Saber saw
   - a. Types
   - b. Uses

C. Tool safety

Show Transparency 33

1. Tool safety rules
   - a. Use the right tool for the job you are doing
   - b. Don't use broken or defective tools
   - c. Keep tools in good repair and properly repaired
   - d. Wear eye protection when soldering, drilling or cutting
   - e. Be sure power tools are properly grounded
   - f. Slow down and think about safety
2. Drill press safety rules
   - a. Always wear eye protection
   - b. Make all adjustments with power off

c. Select the proper bit for the material
d. Always remove the chuck key before turning on power
e. Be sure the speed is not too fast for larger bits
f. Secure loose clothing or long hair
g. Clamp all sheet metal or sharp objects
h. Use a block of wood for a back up

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Hand Tools
2. Assignment Sheet - Hand Tools (Puzzle)
3. The student is to handle the tools and identify each, giving the uses and common misuses of each.
4. Answer any student questions.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions.
2. Test Sheet - Tools
3. 70% correct is required for satisfactory completion of the lesson.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss the test and answer student questions.
2. Review major topics of the presentation.

THE NEXT LESSON IS: Soldering

DRILL PRESS SAFETY RULES

1. Wear eye protection
2. Make adjustments with power off
3. Select the proper bit for the material
4. Always remove the chuck key before turning on power
5. Be sure the speed is not too fast for the material
6. Secure loose clothing or long hair
7. Clamp all sheet metal or sharp objects
8. Use a block of wood for a "back up" to protect table

SAFETY RULES
FOR
USING TOOLS

1. USE THE RIGHT TOOL FOR THE JOB YOU ARE DOING

   Most tools are specialized. Using them outside of that speciality is tool misuse. Don't add "cheaters" to increase leverage. Use screwdrivers to turn screws -- not open cans or substitute for chisels.

2. DON'T USE BROKEN OR DEFECTIVE TOOLS

   Tools that are cracked or worn should be repaired or replaced. Worn power cords are a sign of impending trouble and should be replaced. Only experienced personnel should make repairs on tools or shop equipment. If a strange sound in a tool tells you something is wrong, believe it.

3. KEEP TOOLS IN GOOD REPAIR AND PROPERLY STORED

   Neatness and safety go hand in hand. Every tool should have its place when not in use. Keep the work area tidy, don't use work benches for tool storage. Professionals take care of tools.

4. WEAR EYE PROTECTION WHEN SOLDERING, DRILLING, CUTTING, ETC.

   Never, never risk your eyes by failure to use safety glasses or goggles. Use eye protection and other protection whenever there is a possibility of being struck by flying tools, parts, chemicals, or metal chips.

5. BE SURE POWER TOOLS ARE PROPERLY GROUNDED

   Use power tools only if they have three wire grounding cords or are double insulated. Never use three to two wire adapters without first connecting the ground wire.

6. SLOW DOWN AND THINK ABOUT SAFETY

   Use your head! A moment of thought may save your eye, your finger, your life. Never overcome safety devices. Never mix horseplay with tools or machines. If an accident does occur, get competent medical help at once.

*Source: Jensen Tool Company

TOOL SAFETY

II-C-1a(AS)

Name ______________________________ Date _________________________

DIRECTIONS: Each student is to complete this assignment sheet on an individual basis. List the six safety rules for hand tools which are to be followed in this shop and explain why you feel each is necessary. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

1. ____

____

____

2. ____

____

____

3. ____

____

____

4. ____

____

____

5. ____

____

____

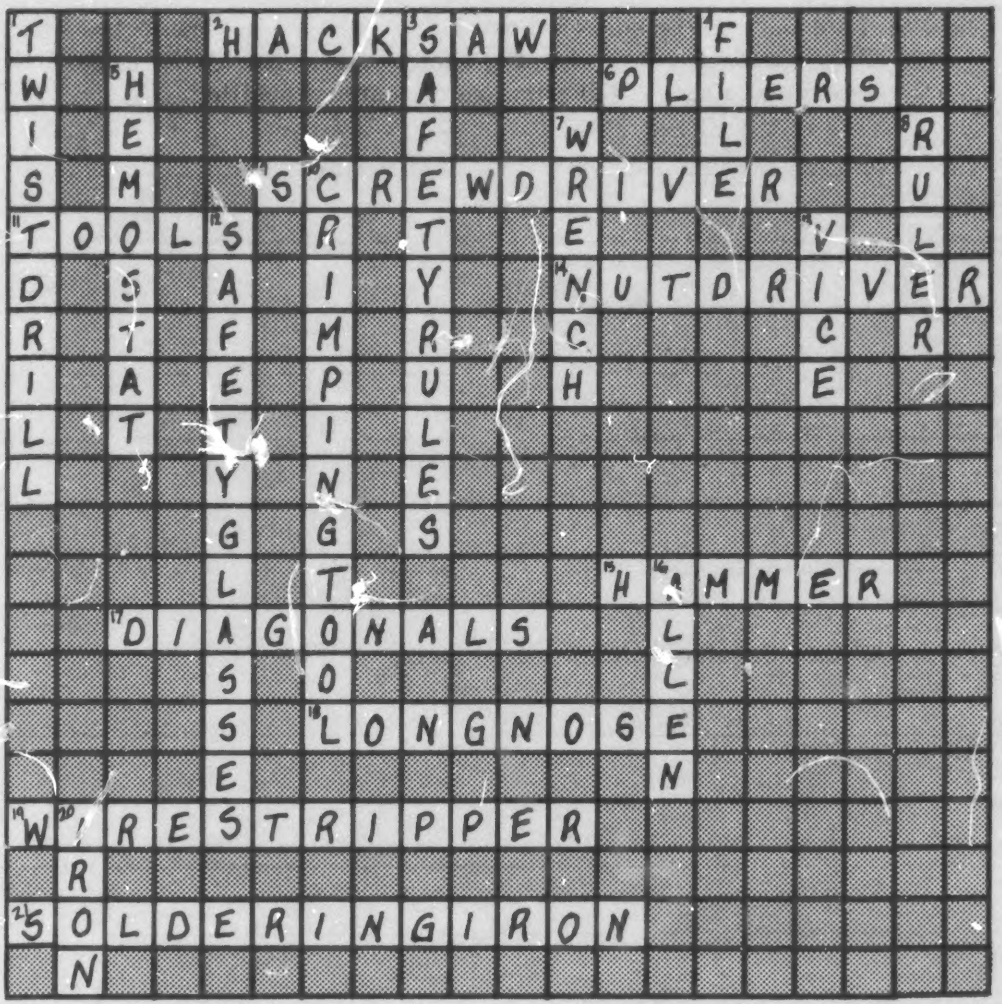
6. ____

____

____

TOOLS

Name ______________________________ Date ______________________________



1 T				2 H	A	C	K	3 S	A	W				4 F					
W		5 H						A				6 P	L	I	E	R	S		
I		E						F			7 W			L				8 R	
S		M			9 S	10 C	R	E	W	D	R	I	V	E	R			U	
11 T	O	O	L	12 S		R		T			E					13 V		L	
D		S		A		I		Y			14 N	U	T	D	R	I	V	E	R
R		T		F		M		R			C					C		R	
I		A		E		P		U			H					E			
L		T		T		I		L											
L				Y		N		E											
				G		G		S											
				L		T						15 H	16 A	M	M	E	R		
		17 D	I	A	G	O	N	A	L	S			L						
				S		O							L						
				S		18 L	O	N	G	N	O	S	E						
				E									N						
19 W	20 I	R	E	S	T	R	I	P	P	E	R								
	R																		
21 S	O	L	D	E	R	I	N	G	I	R	O	N							
	N																		

Across Clues:
2. Cuts metal
6. Channel locks
9. Not for prying
11. Make the job easier
14. Tightens nuts
15. For hitting
17. Wire cutters
18. Pointed pliers (2 words)
19. Removes insulation (2 words)
21. Melts metal alloy (2 words)

Down Clues:
1. Cuts holes (2 words)
3. Helps prevent accidents (2 words)
4. Has teeth and tang
5. Locking pliers
7. For tuning bolts
8. Measure
10. Apply terminals (2 words)
12. Eye protection (2 words)
13. Holds work
16. Hex shape
20. Melts solder

TEST

Name ______________________________ Date ______________________________

DIRECTIONS: Laid out on the lab bench are fourteen hand tools numbered 1 to 14. When it is your turn, identify each tool in order by its proper name. Be sure to check your answers for correct spelling.

1.	______________	8.	______________
2.	______________	9.	______________
3.	______________	10.	______________
4.	______________	11.	______________
5.	______________	12.	______________
6.	______________	13.	______________
7.	______________	14.	______________

Directions: List the six safety rules for hand tools.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Soldering
AIM:	Upon successful completion of the lesson, the student will be able to: select the proper soldering equipment and materials for a specific soldering operation; make satisfactory terminal and printed circuit solder connections; desolder connections for component replacement and properly care for soldering tools.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies fig. 34-40, completed solder practice board
MATERIALS:	Assignment Sheet - Soldering Task Sheet - Solder Practice Board Test Sheet - Soldering Solder Practice Board Flux Coated Braid (12") #22 AWG Rosin Core Solder (3') #22 AWG Tinned Copper Bus Wire (3') #24 AWG Tinned Copper Bus Wire (3') Solder Terminals (2) and Pop Rivets (4)
TOOLS AND EQUIPMENT:	Safety glasses, soldering iron, holder and sponge, circuit board vise, small wire cutters, long nose pliers, soldering aid
REFERENCE:	Soldering: A Self-Instructional Manual, Heath Company, 1977
PREREQUISITE EXPERIENCE OF THE LEARNER:	Shop safety and tools

I. PREPARATION (OF THE LEARNER - MOTIVATION)

One of the most important skills an electronics technician can have is the ability to make good solder connections. You may someday find yourself assembling, repairing or troubleshooting a piece of electronic equipment. The skill of soldering will be used by you in doing your job. Poor solder connections are the cause of many electronic circuit failures. You can prevent these by learning how to make excellent solder connections.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Definitions Show Transparency figs. 34-35	1. The process of bonding together two or more metals by applying a tin-lead alloy called solder

2. In electronics, soldering is used to provide a good electrical connection that is also strong physically
3. Soldering is a fast, easy, low cost, commonly used, reliable method for interconnecting electronic parts

B. Solder

1. Solder is an alloy or mixture of tin and lead
2. Solder is ideal for joining electronic parts because it melts at a low temperature
3. Melting temperature depends on the tin/lead ratio
4. 60/40 tin/lead solder melts at approximately 370°F, has a brief plastic state and becomes solid at 361°F
5. Eutectic solder (63/37) melts at the lowest temperature and does not have a plastic region
6. Wetting is the molecular bond between the solder and the metal pieces

C. Flux

Show Transparency figs. 36-37

1. Oxidation on the surface of a material, caused by exposure to oxygen, will prevent the solder from bonding
2. Flux is a chemical that removes surface oxide from materials
3. Flux comes in many forms, most common for electronics is in a "core" within the wire solder
4. Acid flux will damage electronic circuits and must never be used
5. Rosin flux is the type for electronics work
6. Dirt, grease and other matter must be removed by other means

D. Equipment

1. Soldering irons are used to heat the materials to be soldered
2. Pencil type is most common style
3. 25 to 30 watt heating element is used for printed circuit work
4. Soldering guns give an instant heat but get too hot for most electronics work
5. A damp solder sponge is used to wipe the tip to remove excess solder and dirt buildup
6. Tinning the tip is coating the tip with a layer of solder
7. Iron holders are used to hold the hot irons to prevent burns

II. PRESENTATION (CONT'.)

E. Soldering

Show Transparency fig. 38

1. Wear eye protection
2. Make physical connection
3. Clean iron tip
4. Heat all pieces
5. Apply solder and allow to flow
6. Remove tip and solder
7. Inspect

F. Desoldering

1. Vacuum bulb - heat connection with iron and suck solder off with bulb
2. Desoldering iron - iron and vacuum bulb built together
3. Flux coated braid - braided copper wire coated with rosin flux which will remove solder by capillary action
    a. Place braid over connection
    b. Heat braid and solder
    c. Allow solder to flow on braid
    d. Remove and trim end of braid

G. Inspection

Show Transparency figs. 39-40

1. Cold solder connection - dull and crumbly appearance caused by insufficient heat
2. Rosin solder connection - solder does not flow due to lack of heat leaving flux between materials.
3. Excessive solder - cannot see the pieces soldered, use less solder
4. Solder bridges - excessive solder "shorting" two conductors on a circuit board
5. Too much heat will damage components and wire insulation and circuit boards

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Soldering
2. Task Sheet - Solder Practice Board
3. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - Soldering
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

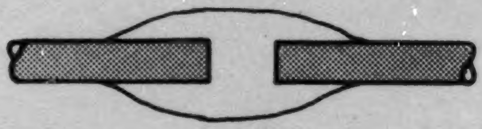
1. Discuss the test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Circuit Construction

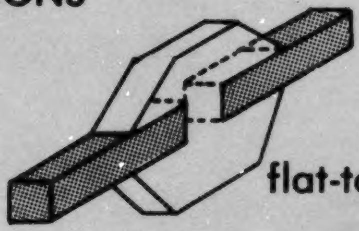
SOLDERED CONNECTIONS

No mechanical security prior to soldering

BUTT CONNECTIONS

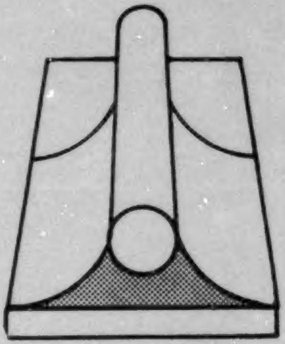


wire-to-wire

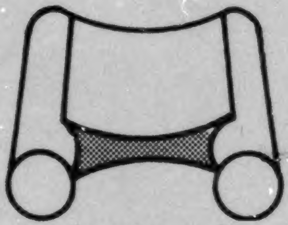


flat-to-flat

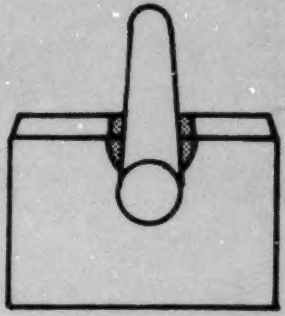
LAP CONNECTIONS



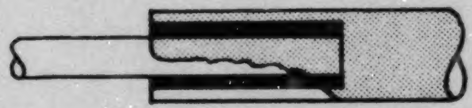
wire-to-flat



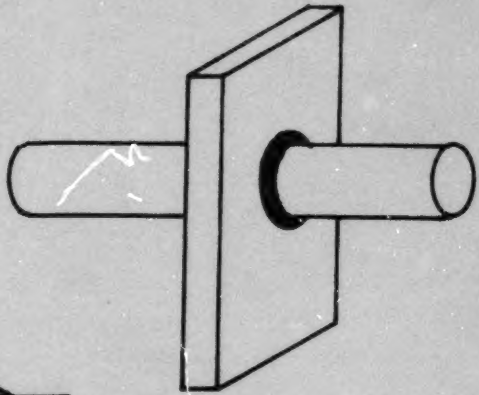
wire-to-wire



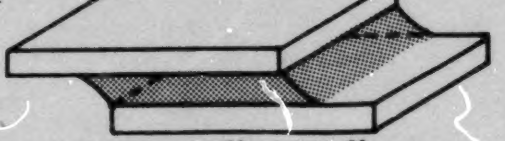
wire-to-post



wire-to-cup or sleeve



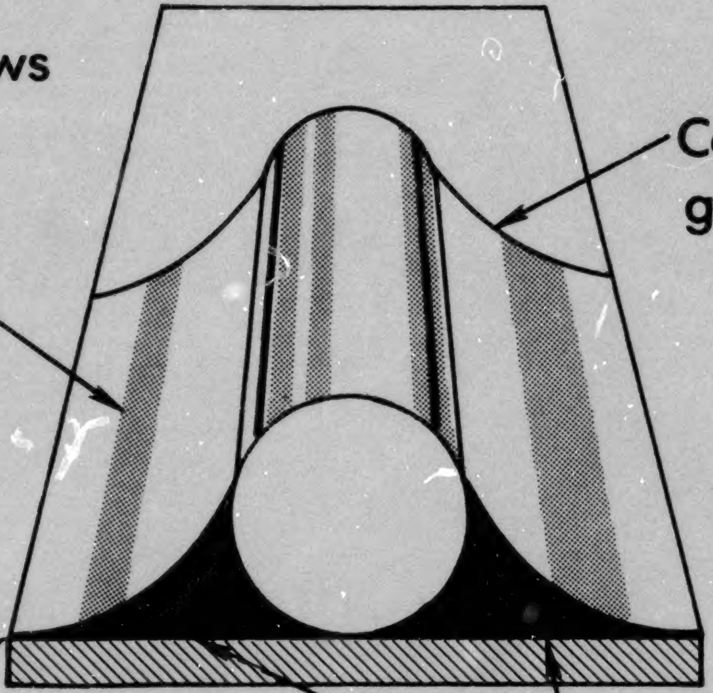
wire-to-hole



flat-to-flat

Fig. 34

PROPER SOLDER JOINT



Shiny surface shows good use of heat

Convex angle shows good wetting

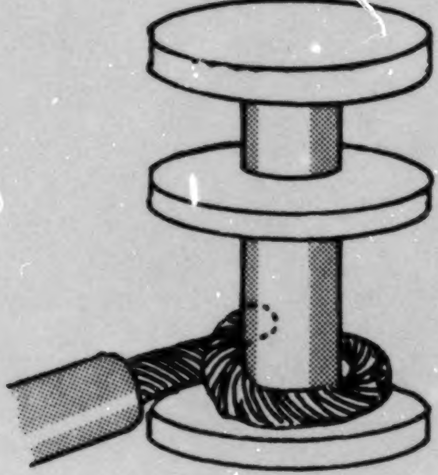
No gaps shows good use of heat and flux

Continuous flow shows good wetting

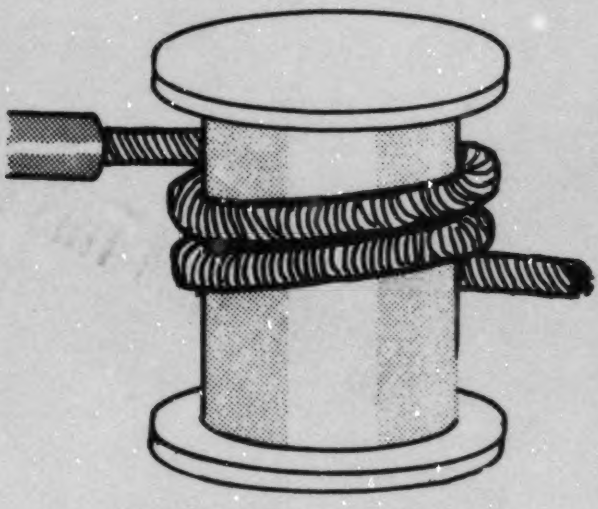
Fig. 35

MECHANICAL CONNECTIONS

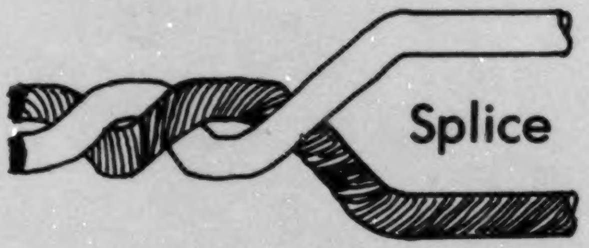
Secure Before Soldering



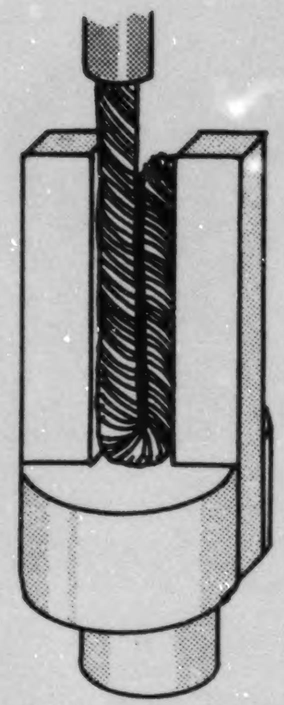
Turret Terminal



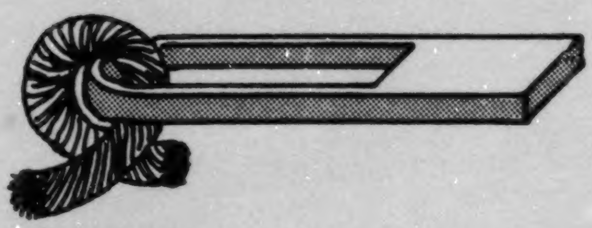
Post Connection



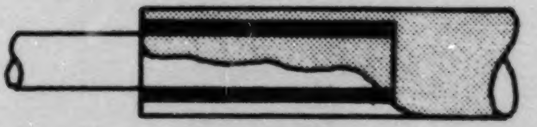
Splice



Bifurcated Terminal



Flat Lug

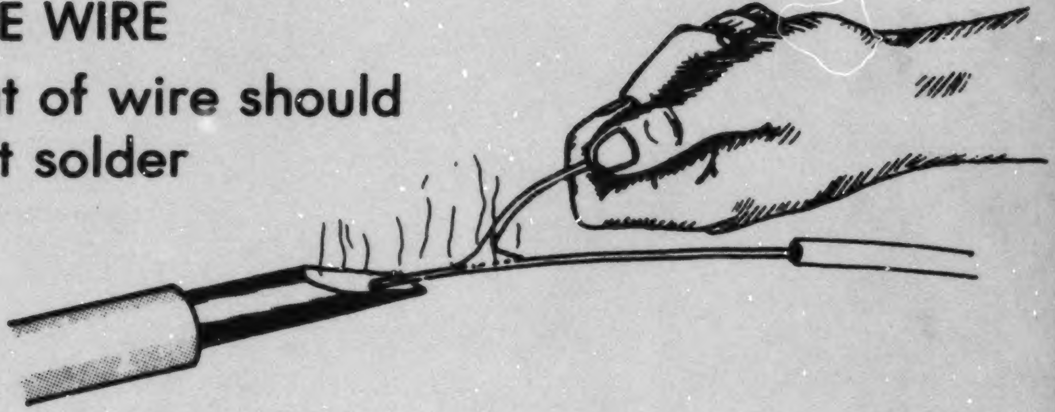


Crimp Sleeve Connection

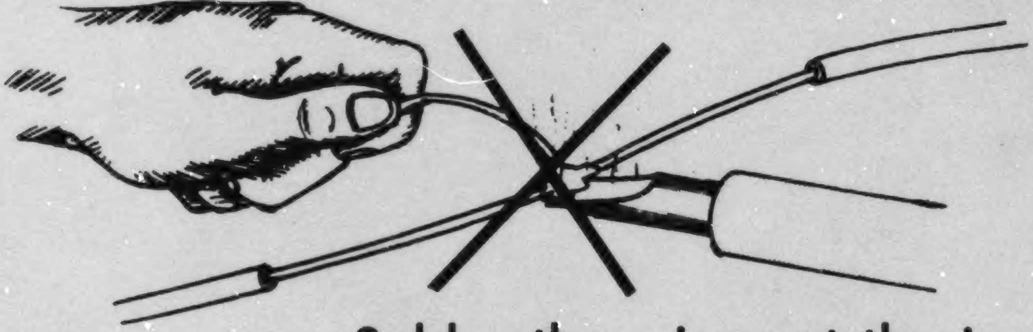
SOLDERING TECHNIQUES

TIN THE WIRE

Heat of wire should
melt solder

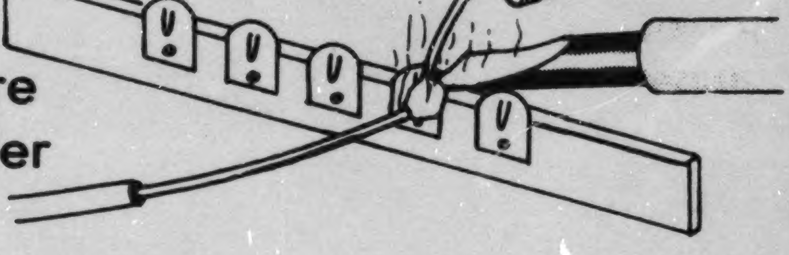


WIRE TO WIRE CONNECTION



Solder the wire not the iron

WIRE TO TERMINAL CONNECTION



Terminal and wire
should melt solder

Fig. 37

STEPS FOR GOOD SOLDER CONNECTIONS

1. Wear eye protection
2. Make physical connection
3. Clean iron tip
4. Heat all pieces
5. Apply solder and allow to flow
6. Remove tip and solder
7. Inspect

CAUSES OF SOLDER CONNECTION FAILURE

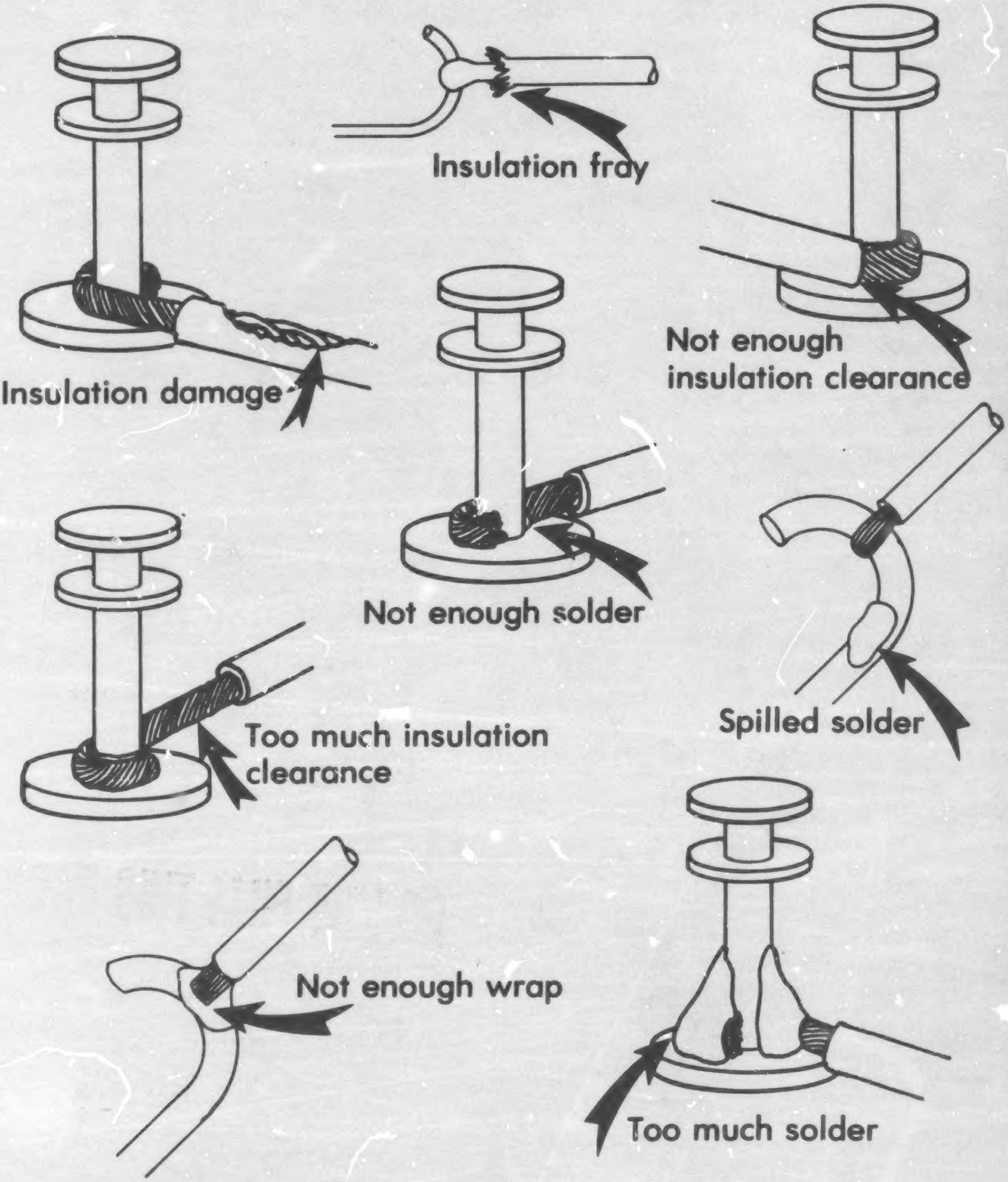

Insulation fray
Insulation damage
Not enough insulation clearance
Not enough solder
Too much insulation clearance
Spilled solder
Not enough wrap
Too much solder

Fig. 39

SOLDER PRACTICE BOARD

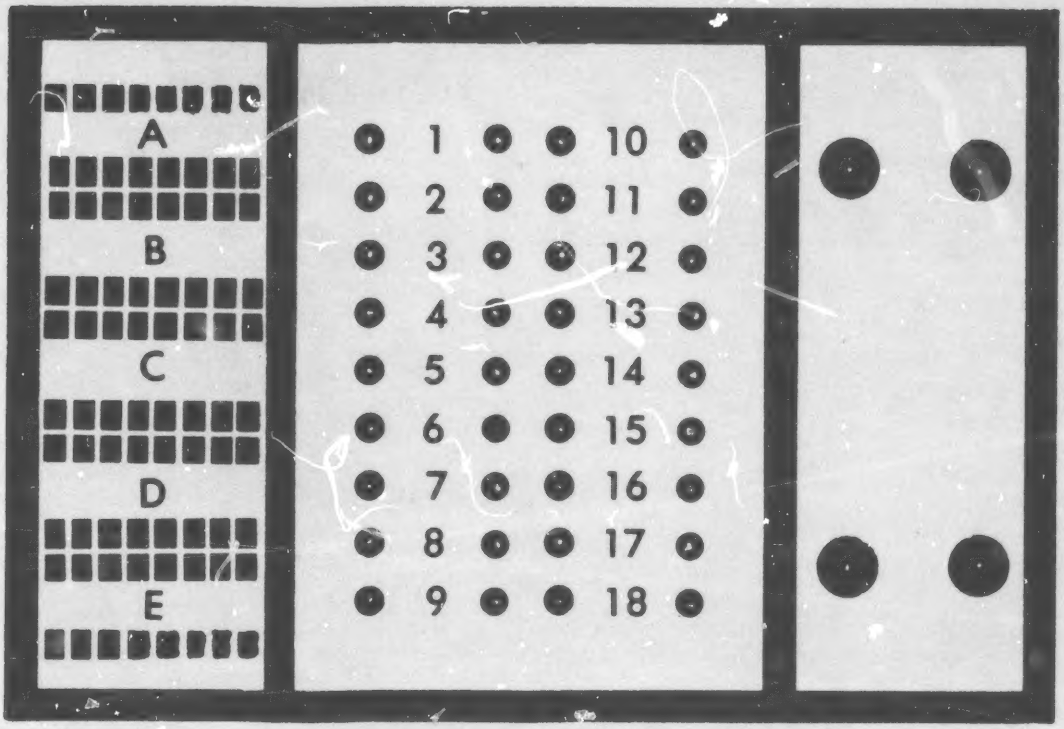

A
B
C
D
E
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Fig. 40

SOLDERING

II-D-1(AS)
Key

Name ______________________________ Date __________________________

DIRECTIONS: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Check your answers to be sure they are correct. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

Soldering	1. The process of ____ is used in electronics to make reliable component connections.
Wetting	2. The bond that takes place between solder and other metals is called ____.
Tin/Lead	3. The ____ ratio determines the melting temperature of solder.
60/40	4. The solder alloy most commonly used in electronics is ____.
370	5. Most solder melts at a temperature of approximately ____ °F.
Flux	6. The chemical cleaning of oxide from metal parts is done using solder ____.
Rosin	7. Only ____ solder flux can be used for electronics and electrical work.
Pencil	8. Most soldering of electronic components is done with an ____ style soldering iron.
25 - 30	9. A soldering iron with a ____ watt rating should be used to prevent component damage.
Gun	10. With its instant high heat feature, a soldering ____ can damage small components.
Clean	11. To make consistently good connections, you should ____ your soldering iron tip each time you pick it up.
Smooth	12. Good solder connections should look ____ and shiny.
Solder	13. Most bad solder connections are caused by excessive ____ or not enough heat.

Eye protection	14. Always wear ____ when soldering or cutting wire.
Braid	15. Two common methods of desoldering are the flux coated ____ and the vacuum bulb.
Burns	16. To prevent severe ____, be careful handling hot soldering irons.
Cooling	17. A solder connection should not be moved during the ____ time.
Damaged	18. Wire insulation, circuit boards and semiconductors are easily ____ by heat.

DIRECTIONS: List the seven steps required to safely make good solder connection in the following spaces.

19. Wear Eye Protection

20. Make Physical Connection

21. Clean Iron Tip

22. Heat All Pieces

23. Apply Solder And Allow To Flow

24. Remove Tip And Solder

25. Inspect

SOLDER PRACTICE BOARD II-D-1(TS)

Name ______________________________ Date __________________________

DIRECTIONS: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed. If you have any questions or problems, ask your instructor.

Safety Note: * Eye protection MUST be worn when soldering and cutting wire.
* Soldering irons are HOT and will burn. BE CAREFUL!

_______ 1. Fasten the six lug terminal strips to the component side of the circuit board using the 1/8" x 1/8" "Pop Rivets".

_______ 2. Using #22 AWG solid, tinned copper wire, make connections between adjacent terminals as demonstrated. Continue to make and remake the connections until all are acceptable connections.

_______ 3. Using the wire strippers, remove about 1/2" of insulation from the end of a piece of #22 AWG stranded wire. Tin the wire. Cut the wire so the overall length is about 1 1/2". Repeat this until you have 6 acceptable pieces tinned.

_______ 4. Connect and solder each of these pieces to a terminal. Use the example board to determine which of the terminals to use.

_______ 5. Using #22 AWG solid, tinned copper wire, make 18 jumper wires to fit between the pad pairs #1 through #18.

_______ 6. Install the jumper wires in pad pairs #1 through #6. Solder and trim the excess lead length.

_______ 7. Install the jumper wires in pad pairs #7 through #18. Solder and trim the excess lead length. Desolder and remake all unacceptable connections.

_______ 8. Using #24 AWG solid, tinned copper wire, make 40 jumper wires to fit between the pad pairs A through E.

_______ 9. Install the jumper wires in the A section pad pairs. Solder and trim the excess lead length.

_______ 10. Install the jumper wires in the B section pad pairs. Solder and trim the excess lead length. Desolder and remake all unacceptable connections.

_______ 11. Install the jumper wires in the remaining pad pairs. Solder and trim the excess lead length. Desolder and remake all unacceptable connections.

TEST

II-D-1(T)
Key

Name ____________________ Date ____________________

DIRECTIONS: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Check your answers to be sure they are correct.

Eye protection ____ 1. Always wear ____ when soldering or cutting wire.

Soldering ____ 2. The process of ____ is used in electronics to make reliable component connections.

60/40 ____ 3. The solder alloy most commonly used in electronics is ____.

Tin/Lead ____ 4. The ____ alloy ratio determines the melting temperature of solder.

Rosin ____ 5. Only ____ solder flux should be used for electronics and electrical work.

Flux ____ 6. The chemical cleaning of oxide from metal parts is done using solder ____.

Wetting ____ 7. The bond that takes place between solder and other metals is called ____.

Pencil ____ 8. Most soldering of electronic components is done with a ____ style soldering iron.

25 - 30 ____ 9. A soldering iron with a ____ watt rating should be used to prevent component damage.

Clean ____ 10. To make consistently good connections, you should ____ your soldering iron tip each time you pick it up.

Shiny ____ 11. Good solder connections should look smooth and ____.

Heat ____ 12. Most bad solder connections are caused by excessive solder or not enough ____.

Braid ____ 13. Two common methods of desoldering are the flux coated ____ and the vacuum bulb.

DIRECTIONS: List the seven steps required to safely make a good solder connection in the following spaces.

14. Wear Eye Protection

15. Make Physical Connection

16. Clean Iron Tip

17. Heat All Pieces

18. Apply Solder And Allow To Flow

19. Remove Tip And Solder

20. Inspect

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT: Circuit Construction

AIM: Upon successful completion of the lesson, the student will be able to layout and construct circuits on socketboards, on perforated boards, using wire wrap and on single sided printed circuit boards.

TEACHING AIDS: Chalkboard, overhead projector, demonstration circuits, Transparencies 19500, figs. 41-42

MATERIALS:
Information Sheet - Socketboards
Information Sheet - Wire Wrap
Information Sheet - Semiconductor Components
Task Sheet - LED Flasher
Task Sheet - Anticipation Tester
Task Sheet - Continuity Checker

TOOLS AND EQUIPMENT: All tools and equipment available from tool room

REFERENCES:
Malcolm, Douglas, How to Build Electronic Projects
Printed Circuit Boards, Heath Company, 1980
Wire-Wrap Catalog No. 55548, The Cooper Group

PREREQUISITE EXPERIENCE OF THE LEARNER: Shop safety, hand tools and soldering

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I. PREPARATION (OF THE LEARNER - MOTIVATION)

An electronics technician working in any area of the electronics industry may have to construct circuits in various ways. This lesson will continue throughout the school year and take you through several methods of performing this task. You will also develop your skills in using tools, reading schematic diagrams, handling components, identifying components and using test equipment.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Socketboard Show Transparency fig. 41	1. Socketboards are used to breadboard electronic circuits
	2. Component leads are plugged into the sockets which provide the connection with other components

3. Socket holes have 0.1 inch spacing to provide easy insertion of integrated circuits and other components
4. There are many similar styles available
5. Once the circuit is constructed on the socketboard using the schematic as a guide, the circuit can be easily modified
6. The working circuit can now be built in a more permanent method
7. Caution must be used to prevent damage to the board
   - a. Leads larger than #22 AWG should not be inserted (#22 AWG is best)
   - b. Only solid wire should be used
   - c. Excessive dirt or solder on leads will damage the connectors
   - d. Components that dissipate a lot of heat should be kept away from the plastic body

B. Perforated Board Construction

1. Perforated board provides another approach to circuit construction
2. Used for many prototype projects in industry
3. Hole spacing is usually 0.1 inch to allow insertion of most components
4. Terminals are usually installed in the holes to allow soldering of component leads
5. Component leads can be inserted through the holes and then bent to provide conductors across the board
6. An inexpensive construction method but is difficult to have "connection" side look neat

C. Wire Wrap Construction

1. Used in TV, computer and telecommunications industry for interconnection of equipment
2. Wire is twisted around a metal post or terminal several times
3. Wire wrap provides an excellent method of making high density wire connections
4. Provides low failure rate of connections
5. Steps in making connections
   - a. Strip wire
   - b. Insert wire in wrapping bit
   - c. Anchor wire
   - d. Insert terminal
   - e. Twist (power or manual)
   - f. Inspect

D. Printed Circuit Construction

1. Advantages
   - a. Interconnection of components is predetermined and checked
   - b. Assembly is much faster
   - c. More components can be interconnected in less space
   - d. Overall appearance is very neat

Show Transparency fig. 42

2. Process steps
   - a. Breadboard schematic
     - (1) Check circuit for proper operation
     - (2) Modify for desired operation
   - b. Pencil layout
     - (1) Determine board size
     - (2) Draw components to scale on graph paper
     - (3) Interconnect components as indicated by schematic
     - (4) Double check all connections and component sizes
       - (a) Be sure you followed the schematic
       - (b) Make conductors as short as possible
       - (c) Avoid jumpers
       - (d) Be sure there is a hole for every component lead
3. Artwork
   - a. Trace layout from graph paper to the plastic sheet
   - b. Use place pads and PC tape to make circuit connections
   - c. Be sure a border is on layout to allow handling during the process
   - d. Be sure all corners are neat and tape is pressed down on plastic sheet
4. Negative
   - a. Expose negative film through artwork
   - b. Use ultra-violet light for time indicated in material instructions
   - c. Develop negative as indicated in material instructions
5. Exposing board
   - a. Use pre-sensitized circuit board
   - b. Place negative over copper side
   - c. Expose to ultra-violet light for time indicated in material instructions

6. Develop board

(CAUTION) **** EYE PROTECTION REQUIRED DURING THIS STEP

- a. Place board in glass tray with the copper side up
- b. Pour developer over board
- c. Allow to set for time indicated in material instructions
- d. Rinse in hot water
- e. Blot dry on soft paper towel

7. Etch Board

(CAUTION) **** EYE PROTECTION AND RUBBER GLOVES REQUIRED DURING THIS STEP

- a. Place board copper side up in glass tray
- b. Pour etching solution into tray
- c. Rock tray gently during etching until desired copper is removed
- d. Wash with scouring powder and pad to remove etch and photo-resist
- e. Dry board

8. Drilling

(CAUTION) **** EYE PROTECTION REQUIRED DURING THIS STEP

- a. Drill all holes
- b. Be sure holes are centered in pad area
- c. Be sure holes are the proper size

9. Assembly and checkout

(CAUTION) **** EYE PROTECTION REQUIRED DURING THIS STEP

- a. Insert components in proper location
- b. Solder properly
- c. Check circuit for proper operation

USE: Examples of well and poorly constructed circuts for demonstration

---

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Task Sheet - LED Flasher
2. Task Sheet - Anticipation Tester
3. Task Sheet - Continuity Checker

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

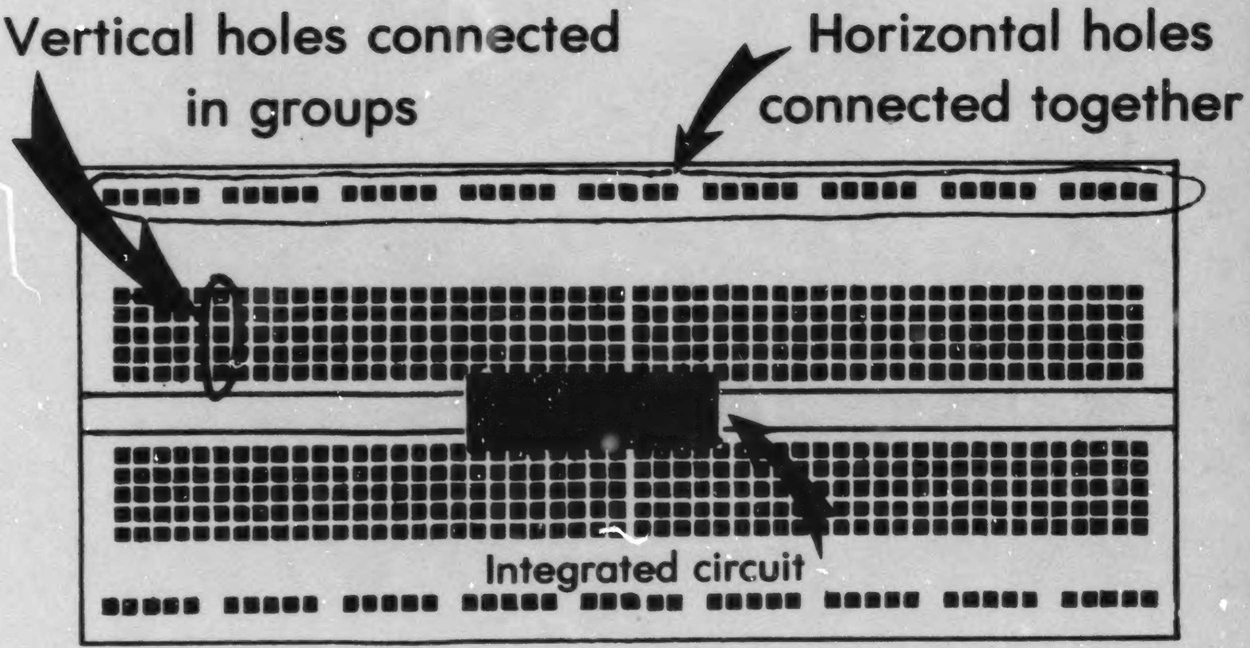
1. Ask oral questions.
2. Evaluate the students work for completeness and neatness.
3. Have students re-work circuits until satisfactory results are obtained.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

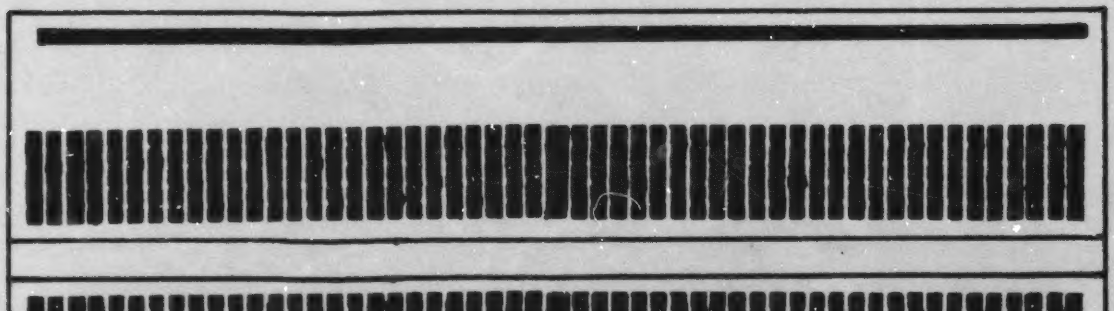
Review the major topics of the lesson presentation

THE NEXT LESSON IS: Electricity

SOCKETBOARD


Vertical holes connected in groups
Horizontal holes connected together
Integrated circuit

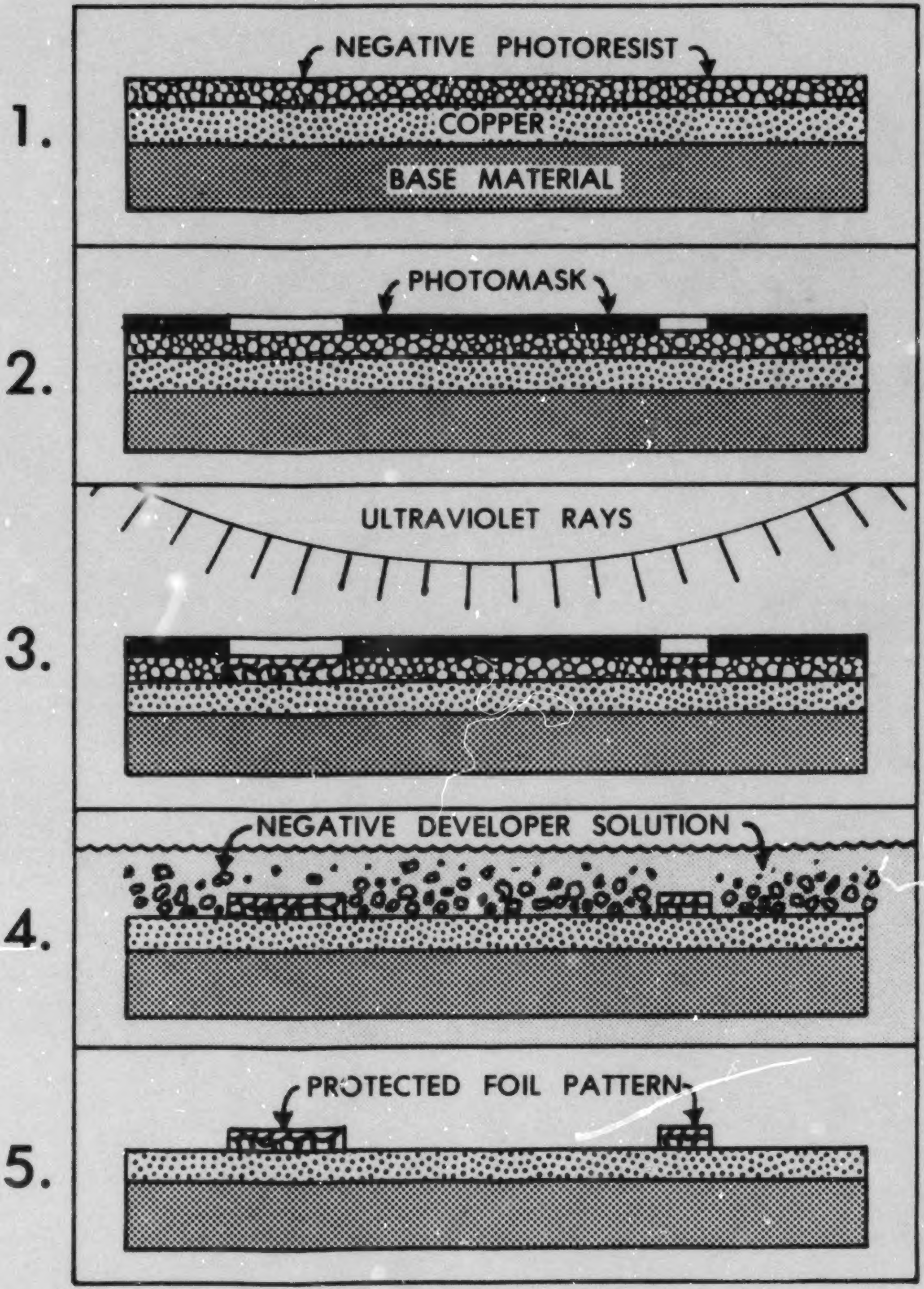
FRONT



BACK

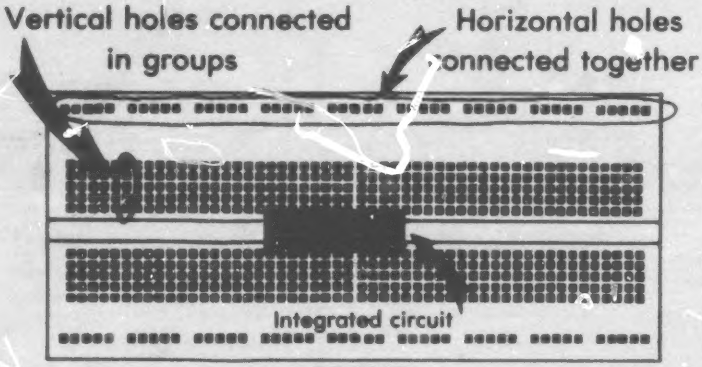
Fig. 41

NEGATIVE-ACTING PHOTORESIST

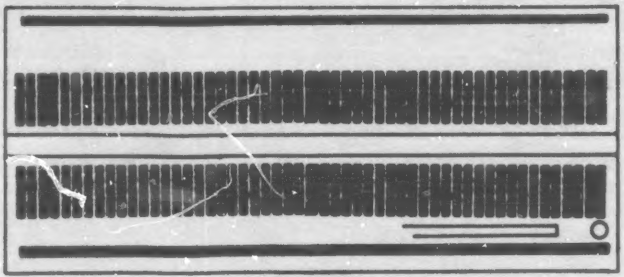

NEGATIVE PHOTORESIST
1.
COPPER
BASE MATERIAL
PHOTOMASK
2.
ULTRAVIOLET RAYS
3.
NEGATIVE DEVELOPER SOLUTION
4.
PROTECTED FOIL PATTERN
5.

Negative Photoresist

One of the most useful devices in experimental electronic circuit construction is the solderless breadboard or socketboard. It allows for fast, easy construction for testing, and when the circuit is perfected, it can be built more permanent by using a printed circuit board or soldered wiring.


Vertical holes connected in groups
Horizontal holes connected together
Integrated circuit

FRONT



BACK

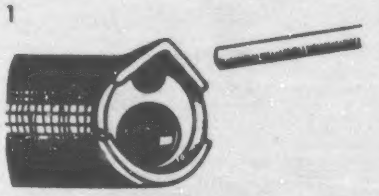
Note the holes in the front of the protoboard which accept component leads. Holes in the horizontal lines are connected on both top and bottom on the back of the board. Components with leads plugged into these strips are thus connected together. This approach is used for vertical hole groups of 5 per each. Component leads up to a maximum of five plugged into these holes will be connected together.

The center channel divides the protoboard and integrated circuits straddle the channel. A component bracket holding lamps, terminals, etc. can be placed in the channel on each edge of the board. Components producing heat should not be placed close to the plastic surface. Solid wire from #20 to #24 AWG should be used.

Wire-Wrap Connection Procedure

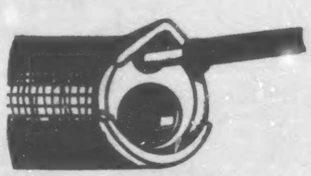
Source: The Cooper Group P.O.Box 728 Apex, NC 27502

STEP 1



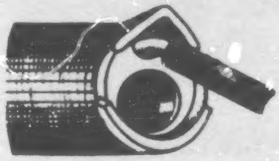
Components: Bit, Sleeve, Stripped Wire

STEP 2



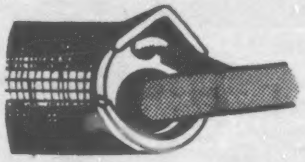
Insertion

STEP 3



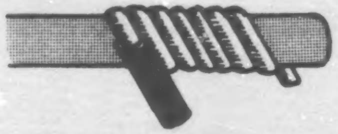
Anchoring

STEP 4



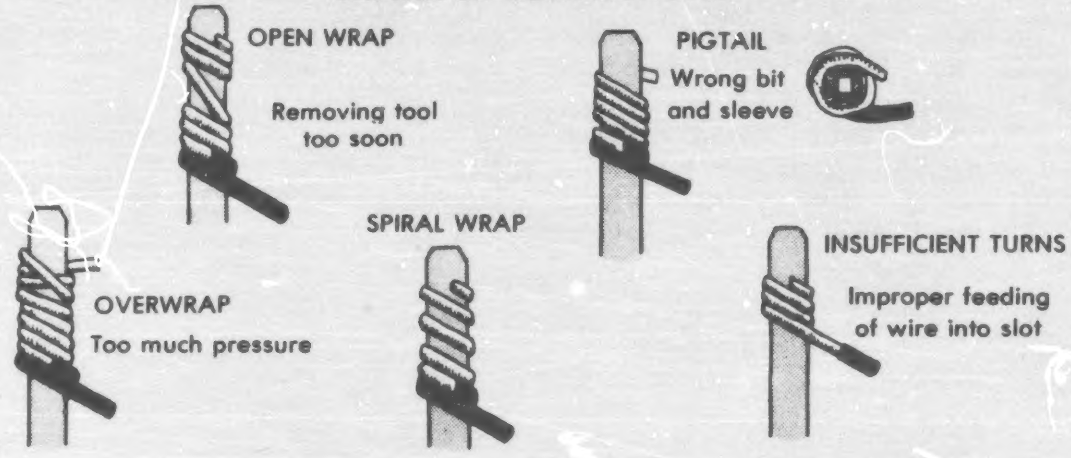
Terminal Insertion

STEP 5



Finished Connection

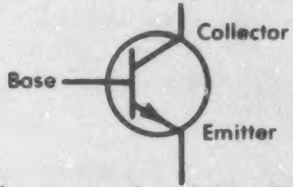
IMPROPER CONNECTIONS


OPEN WRAP
Removing tool too soon
PIGTAIL
Wrong bit and sleeve
SPIRAL WRAP
INSUFFICIENT TURNS
Improper feeding of wire into slot
OVERWRAP
Too much pressure

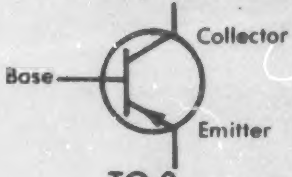
SEMICONDUCTOR INFORMATION

TRANSISTORS

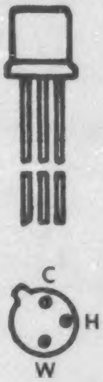
Schematic Symbol - NPN


Collector
Base
Emitter

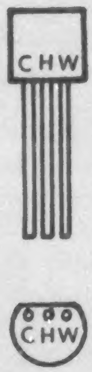
Schematic Symbol - PNP


Collector
Base
Emitter

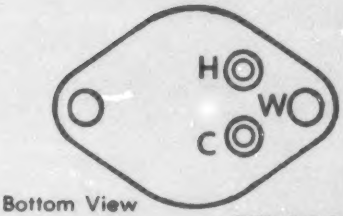
TO-5 TO-18



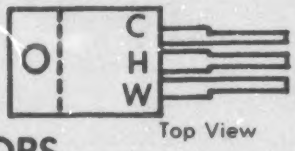
TO-92



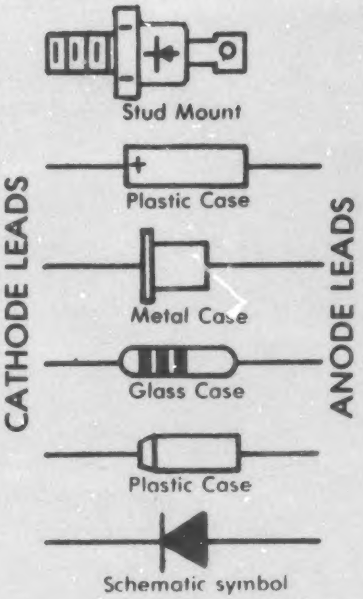
TO-3


H
W
C
Bottom View

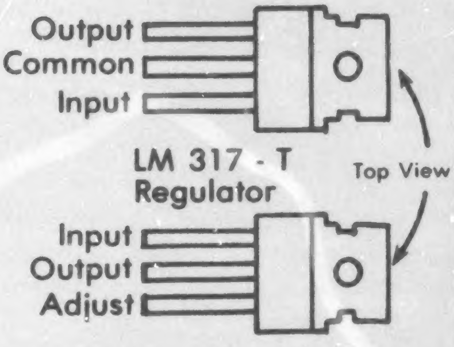
TO-220


C
H
W
Top View

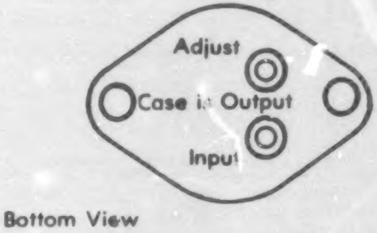
DIODES


Stud Mount
Plastic Case
Metal Case
Glass Case
Plastic Case
Schematic symbol
CATHODE LEADS
ANODE LEADS

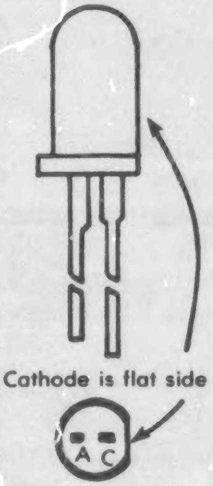
7805 - 5V Regulator

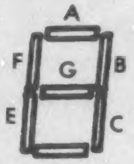

Output
Common
Input
LM 317 - T Regulator
Top View
Input
Output
Adjust

LM 317 - K Regulator


Adjust
Case is Output
Input
Bottom View

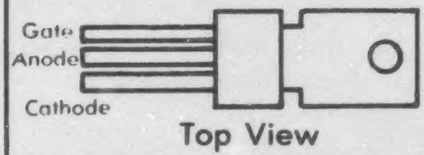
LED


Cathode is flat side
A C

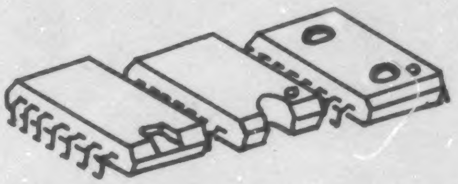


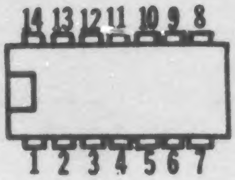
Seven-segment Display

SCR


Gate
Anode
Cathode
Top View

Dip IC Packages




14 13 12 11 10 9 8
1 2 3 4 5 6 7

Top View

LED FLASHER CIRCUIT

Name ______________________ Date ______________________

Directions: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed to help you understand the instructions. If you have any questions or problems, ask your instructor.

Safety Note:

1. Eye protection MUST be worn when soldering and cutting wire.
2. Soldering irons are HOT and will burn. Be careful!
3. To prevent component damage, check for proper connections.

_______ 1. Construct the following circuit on a socketboard using the components in the parts list. Be sure to check your connections. Connect the battery and check for proper operation.

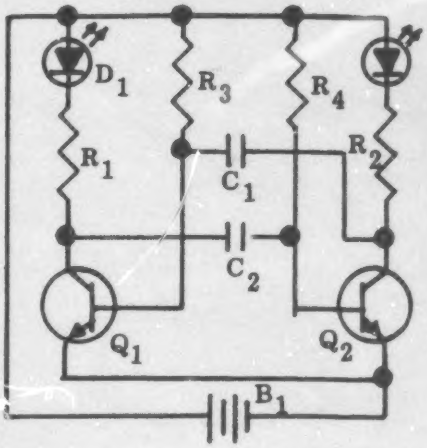
_______ 2. Remove the components from the socketboard and straighten the leads.

_______ 3. Install the components in their proper location using the component layout as a guide. Be sure to check the transistors, LED's and electrolytic capacitors for proper orientation.

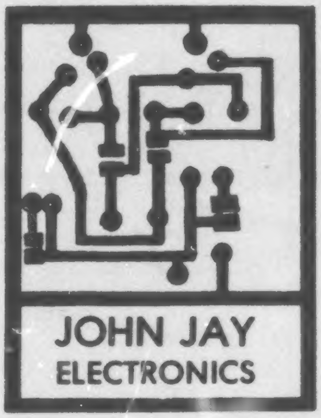
_______ 4. Solder the component leads and trim excess length. Be sure to follow the five steps to insure a good solder connection. Remake any unacceptable connections.

_______ 5. Fasten the battery to the circuit board using double sided tape. Connect the battery to the battery clip and check the circuit for proper operation.

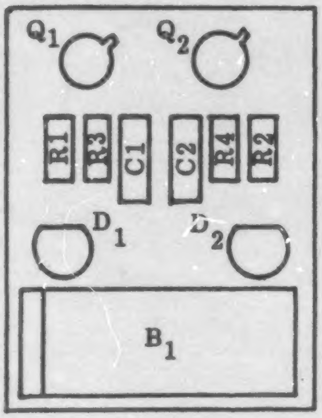
Schematic Diagram:



Board Layout:
(Copper Side)



Board Layout:
(Component Side)



Parts list: R_1-R_2 100 Ohm 1/2W C_1-C_2 10µF@10V D_1-D_2 LED 20 mA Type

R_3-R_4 33K Ohm 1/2W Q_1-Q_2 2N2222 Type B_1 9V with clip

ANTICIPATION TESTER CIRCUIT

II-E-1b (TS)
Key

Name ______________________________ Date ______________________________

Directions: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed to help you understand the instructions. If you have any questions or problems, ask your instructor.

Safety Note:
1. Eye protection MUST be worn when soldering and cutting wire.
2. Soldering irons are HOT and will burn. Be careful!
3. To prevent component damage check for proper connections.

______ 1. Construct the following circuit on a socketboard using the components in the parts list. Be sure to check your connections.

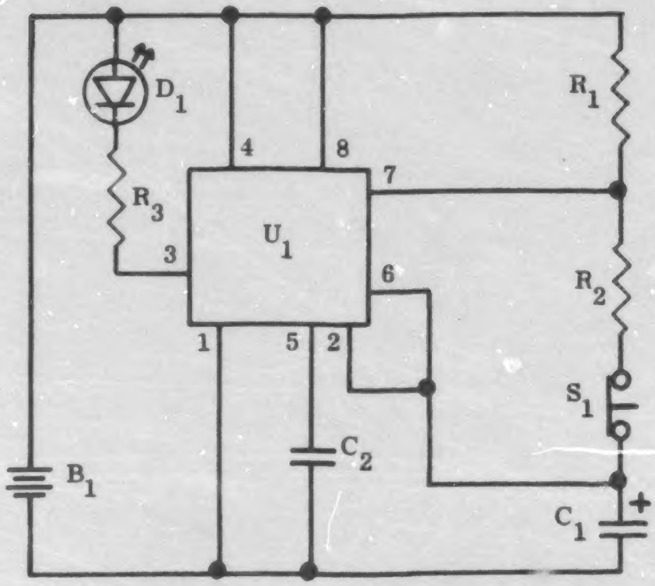
______ 2. Connect the battery to the battery clip. Check the circuit for proper operation.

______ 3. Remove the components from the socketboard and straighten the leads.

______ 4. Using the piece of perforated circuit board, construct the circuit from the schematic diagram. Be sure all components are connected correctly and all solder connections are acceptable.

______ 5. Fasten the battery to the board using double sided tape. Connect the battery to the battery clip. Check the circuit for proper operation.

Schematic Diagram:



Parts List:

C_1	4.7 μF @ 10V
C_2	.01 μF @ 10V
D_1	LED -- 20 mA Type
U_1	555 Timer IC
R_1	470K Ohm ½ W
R_2	22K Ohm ½ W
R_3	220 Ohm ½ W
S_1	PBNC Switch
B_1	9 Volt Battery

Perforated Board, Battery Clip, 8 Pin Dip IC Socket

CONTINUITY CHECKER CIRCUIT II-E-1c(TS)

Name ______________________ Date ______________________

Directions: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed to help you understand the instructions. If you have any questions or problems, ask your instructor.

Safety Note:

1. Eye protection MUST be worn when soldering, cutting, drilling or handling chemicals.
2. Soldering irons are HOT and will burn. Be careful!
3. To prevent component damage, check for proper connections.

______ 1. Construct the following circuit on a socketboard using the components in the parts list. Be sure to check your connections. Connect the battery and check for proper operation.

______ 2. Remove the components from the socketboard and straighten the leads.

______ 3. Do a pencil alyout on graph paper of the circuit. Limit board size to 3" x 4".

______ 4. Do a taped positive artwork of the copper side of the printed circuit board using the pencil layout as a guide.

______ 5. Make a negative from the positive artwork.

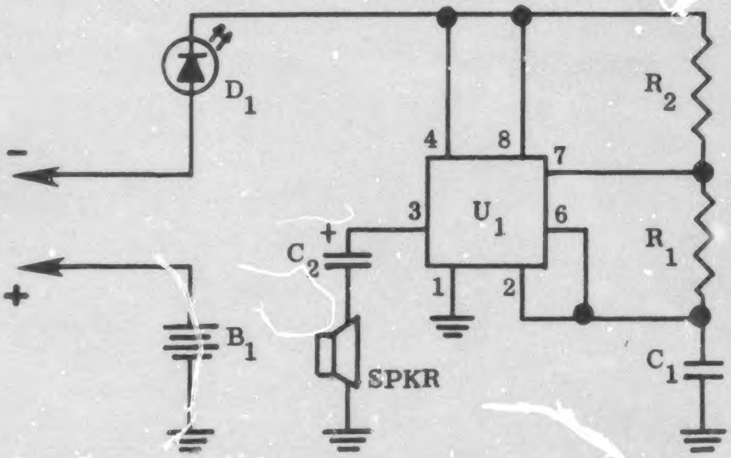
______ 6. Print, etch and drill the circuit board.

______ 7. Assemble the circuit board. Be sure components are installed properly. Check for proper operation.

Parts List:

D_1 LED -- 20 mA Type
R_1 4.7K Ohm ½ W
R_2 1K Ohm ½ W
C_1 .1 μF @ 16V
C_2 10 μF @ 16V
U_1 555 IC
B_1 9 V with Clip
SPKR 8 Ohm -- 1" to 2" Dia.
Set of test leads with clips

Schematic Diagram:



INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Electricity
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate an understanding of atomic structure, electron flow, static electricity, voltage current and sources of electricity through experimentation and answering questions.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500 figs. 43-50
MATERIALS:	Assignment Sheet - Electricity Assignment Sheet - Electricity Terms Experiment #5 - Sources of Electricity Test Sheet - Electricity
TOOLS AND EQUIPMENT:	Student lab station, component set
REFERENCES:	De Vito, Introduction to Electricity and Electronics Fowler, Electricity - Princples and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Have you ever seen the spark produced after you walked across a carpet and then touched a light switch or other object? What causes this spark? Is it dangerous? These and other questions will be answered in this lesson. You will learn about atomic principles, principles of electron flow and static electricity. How many sources of electricity are there that can be used by people? What is the source of electricity for the lights in this room? What source of electricity operates a flashlight? Can sunlight or heat be used to produce electricity? You will discover the answers to these questions and learn that there are many sources of electricity. You will learn to classify them in four different groups: chemical, mechanical, thermoelectric, and photoelectric.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Structure of Matter	1. Based on atomic theory (not law) 2. Matter is anything that occupies space and has mass. All solids, liquids and gases

3. Matter is composed of atoms
4. Atoms are the smallest particle that matter can be divided into and still retain its chemical properties
5. Atoms are too small to see -- its behavior is only known by the results of tests and experiments

Show Transparency fig. 43

6. Parts of the atom
   - a. Nucleus - the center of the atom containing protons and neutrons
   - b. Proton - positively charged particles
   - c. Neutron - neutrally charged particles
   - d. Electron - negatively charged particle that forms the outside part of the atom. Orbits around the nucleus
7. Ions
   - a. Positive ion - positively charged atom due to more protons than electrons
   - b. Negative ion - negatively charged atom due to more electrons than protons
8. Valence electrons - electrons in outer most shell or orbit

Show Transparency fig. 44

9. Free electrons - an electron that can move from one atom to another

B. Conductors and Insulators

1. Conductors are materials with many free electrons
2. Example of conductors
   - a. Copper and aluminum are used because they are less expensive
   - b. Gold and silver are good conductors but are too expensive for general use
3. Insulators are materials with very few free electrons
4. Examples of insulators
   - a. Glass, rubber, plastic and mica
   - b. Insulators are used around conductors so free electrons will stay in the path of the conductor

C. Static Electricity

Show Transparency fig. 45

1. The deficiency or excess of electrons on an object
2. Static electricity is usually caused by friction on an object

Show Transparency fig. 46

3. Example - glass rod rubbed with silk cloth (Rod + Cloth -)

4. Electrostatic induction - a static charge on an object can be used to positively or negatively charge another object
5. Static discharge - when a static charge becomes great enough, electrons will move from the negative to the positive point which has a lack of electrons

D. Electrical Charge

1. Charge is the lack of electrons (+) or excess of electrons (-) on an object
2. Symbol: Q

Show Transparency fig. 47

3. Unit: coulomb, C
4. Coulomb = 6.25×10^{18} electrons
5. An object with a deficiency of 6.25×10^{18} electrons has a positive one coulomb charge
6. Law of charges: like repel and unlike attract

E. Current Flow

1. The movement of charged particles in a specific direction
2. Symbol: I
3. Unit: Ampere, A
4. One ampere of current is equal to one coulomb of electrons moving past a given point in one second
5. Formula: $I = Q/t$
6. Examples
   a. 6 C in 1 sec, $I = Q/t = 6/1 = 6A$
   b. 0.05 C in 1 sec, $I = Q/t = 0.05/1 = 50mA$
7. Speed of electron flow is approximately the speed of light
8. Current types
   a. Direct current (DC) is in one direction only
   b. Alternating current (AC) periodically reverses direction

F. Voltage

Show Transparency fig. 48

1. Pressure which causes current to flow
2. Voltage is also known as electromotive force (EMF) or potential difference
3. An electric charge possesses potential energy. A potential difference exists between two objects with different charges
4. Symbol: V or E
5. Unit: volt, V
6. One volt is the amount of potential difference required to move one coulomb on charge.
7. Current will flow from the more negative to the more positive object of terminal

G. EMF in Series and Parallel

1. Series - placed end to end
   a. Aiding - connected + to - will increase overall voltage
   b. Opposing - connected + to + or - to - will decrease voltage
2. Parallel - placed side by side (+ to + or - to -) will neither increase or decrease voltage but increases electron flow capacity

H. Electric Circuit

1. For current to flow
   a. Must have a source of potential difference
   b. Must be a complete path for current flow
2. Open circuit has incomplete path for current
3. Short circuit has a shortened path for current - does not flow through the complete path

I. Sources of Voltage (Energy Conversion)

Show Transparency fig. 49

1. Chemical - converts chemical energy into electrical energy
   a. Voltaic cell - wet cell - two dissimilar metal strips placed in an acid solution. Produces 1.5 V of potential difference
   b. Lead acid - storage batteries - car type several wet cells in series to increase voltage. High current capacity and can be recharged
   c. Dry cell - carbon/zinc uses a paste instead of liquid for electrolyte and has output of 1.5V. Used for low voltage and low current applications
   d. Batteries - two or more cells connected together to increase the voltage or current capacity
2. Mechanical

Show Transparency fig. 50

   a. Generator - converts mechanical motion (energy) to electrical energy. Uses magnetism
   b. Piezoelectric crystal - certain crystal materials such as quartz generate a voltage when subjected to mechanical vibration or stress
3. Photoelectric - photovoltaic or solar cell converts light energy to electrical energy
4. Thermoelectric - a device which converts heat to electrical energy. Most common is the thermocouple

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Electricity
2. Assignment Sheet - Electricity Terms
3. Experiment #5 - Sources of Electricity

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - Electricity
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions.
2. Review the major topics of the lesson presentation.

THE NEXT LESSON IS: Resistance

PARTS OF AN ATOM

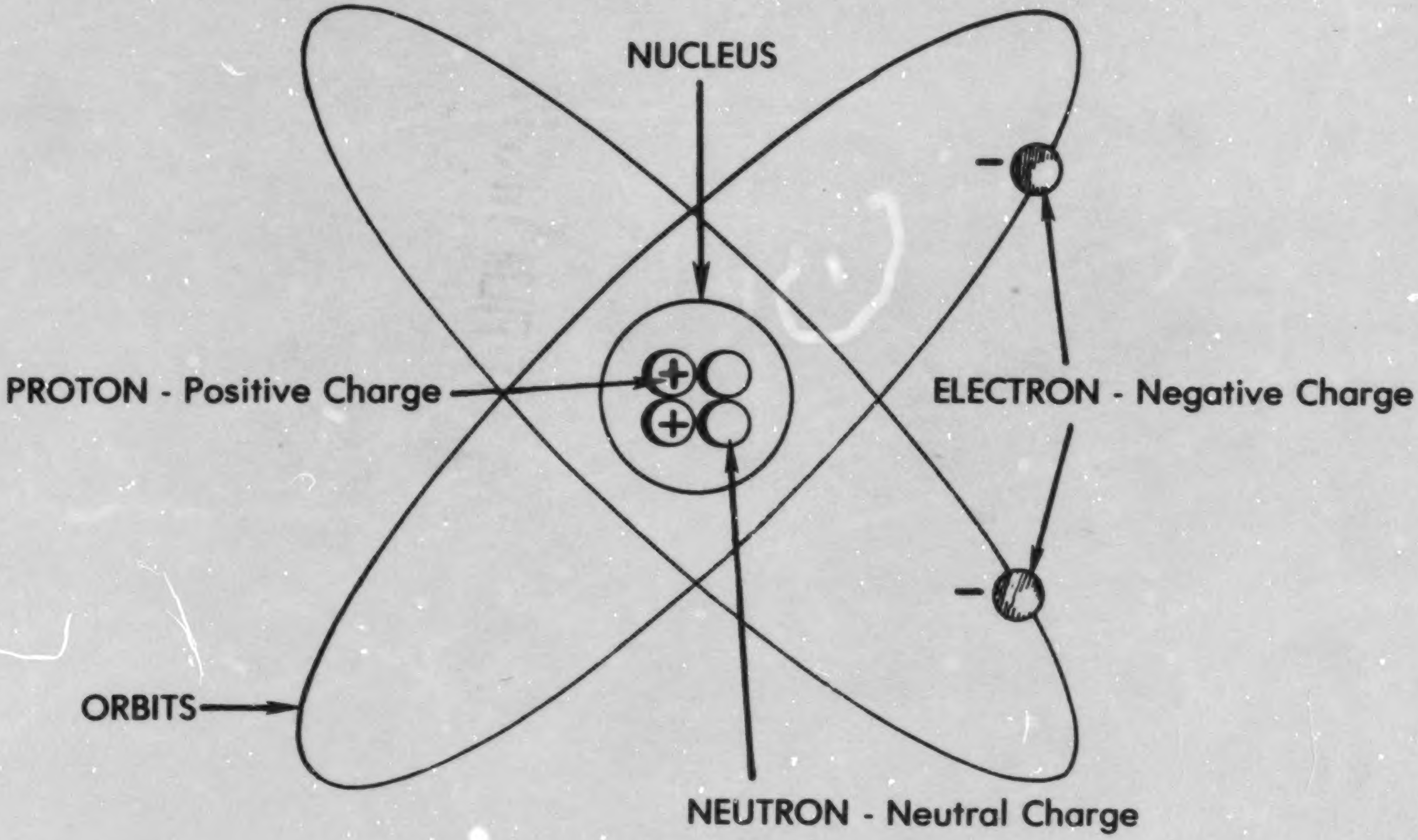
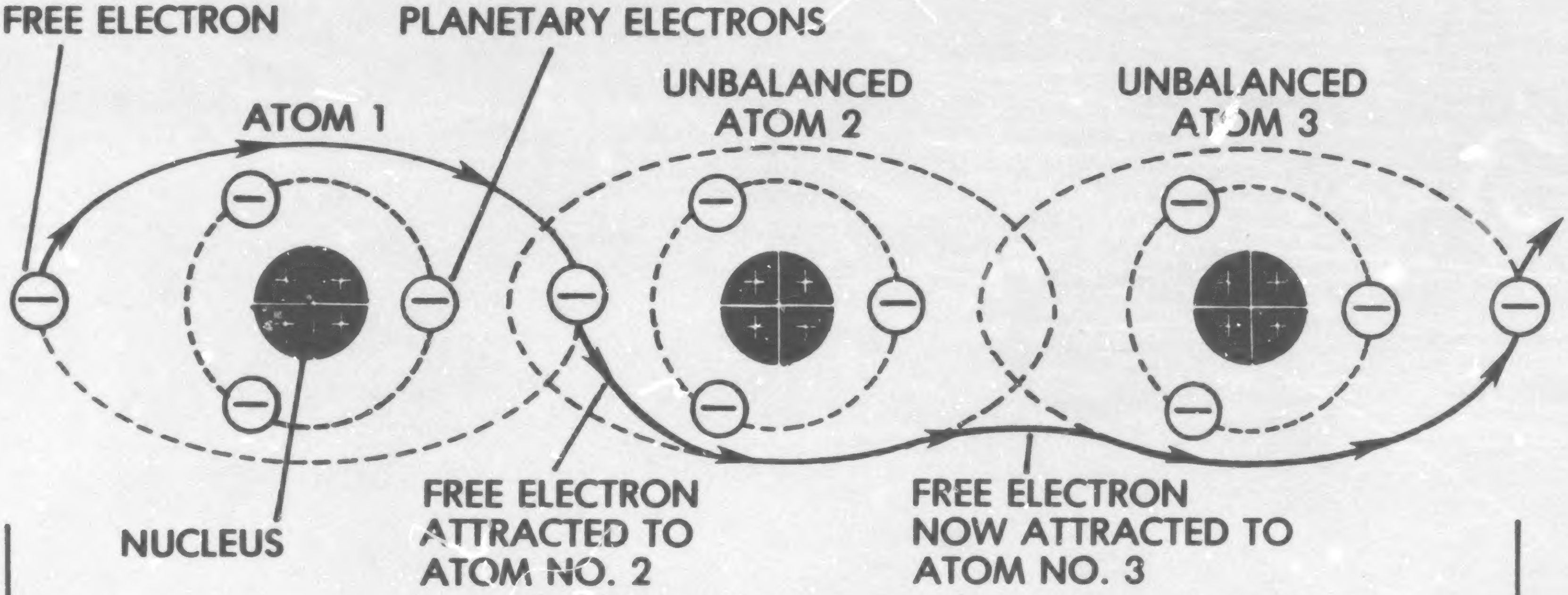

NUCLEUS
PROTON - Positive Charge
ELECTRON - Negative Charge
ORBITS
NEUTRON - Neutral Charge

Fig. 43

FUNDAMENTALS OF ELECTRICITY


FREE ELECTRON
PLANETARY ELECTRONS
ATOM 1
UNBALANCED ATOM 2
UNBALANCED ATOM 3
FREE ELECTRON ATTRACTED TO ATOM NO. 2
FREE ELECTRON NOW ATTRACTED TO ATOM NO. 3
NUCLEUS

FREE ELECTRON TRAVEL

FREE ELECTRONS MOVE FROM UNBALANCED ATOM TO UNBALANCED ATOM.
MATTER THAT DOES NOT READILY RETAIN ITS ELECTRONS IS A CONDUCTOR.
MATTER THAT DOES RETAIN ITS ELECTRONS IS AN INSULATOR.

STATIC ELECTRICITY

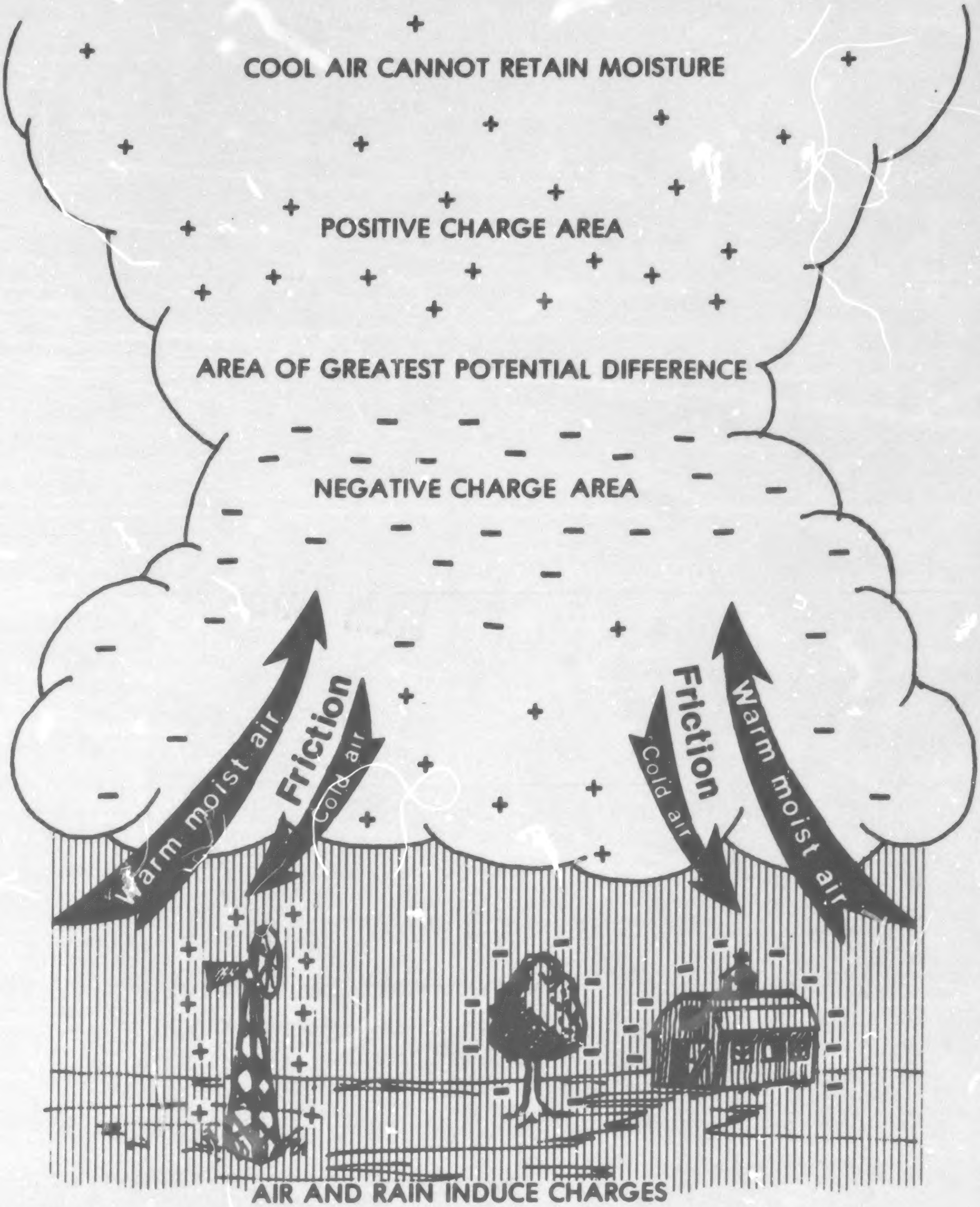
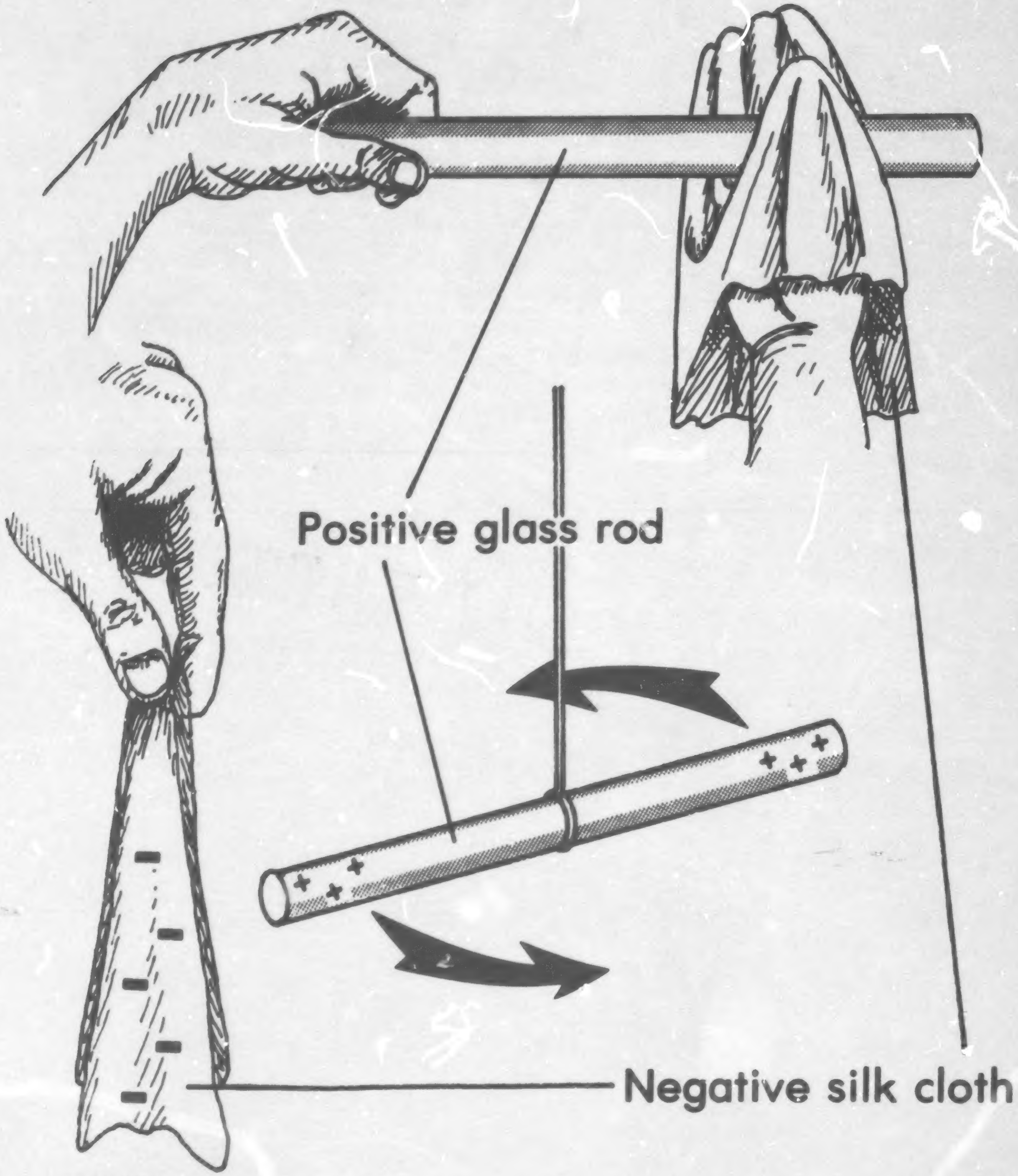
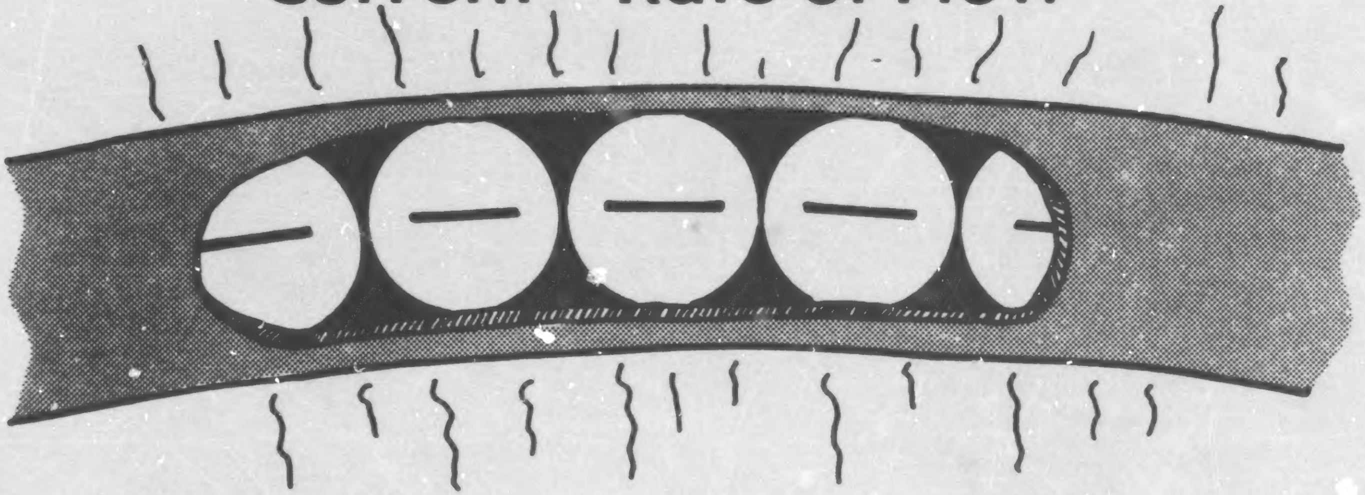

COOL AIR CANNOT RETAIN MOISTURE
POSITIVE CHARGE AREA
AREA OF GREATEST POTENTIAL DIFFERENCE
NEGATIVE CHARGE AREA
Warm moist air
Friction
Cold air
Friction
Cold air
Warm moist air
AIR AND RAIN INDUCE CHARGES

Fig. 45

STATIC ELECTRICITY BY FRICTION

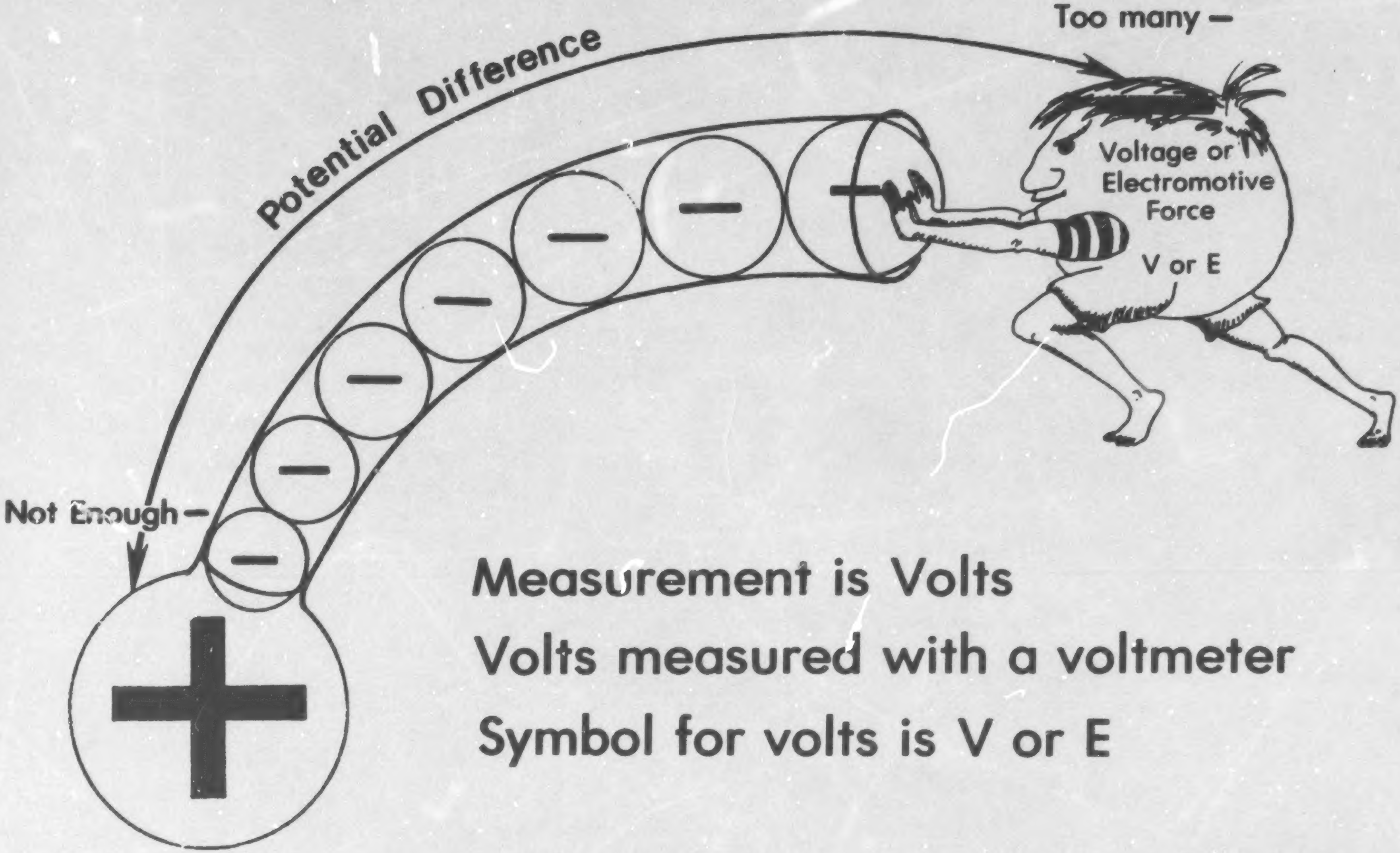

Positive glass rod
+ + +
+ + +
- - - - -
Negative silk cloth

Current = Rate of Flow



- Number of electrons passing through a conductor is termed current flow.
- One coulomb = 6.28×10^{18} electrons passing through in one second = Ampere.
- Amperes measured with an ammeter.
- Symbol for amperes is I.

VOLTAGE

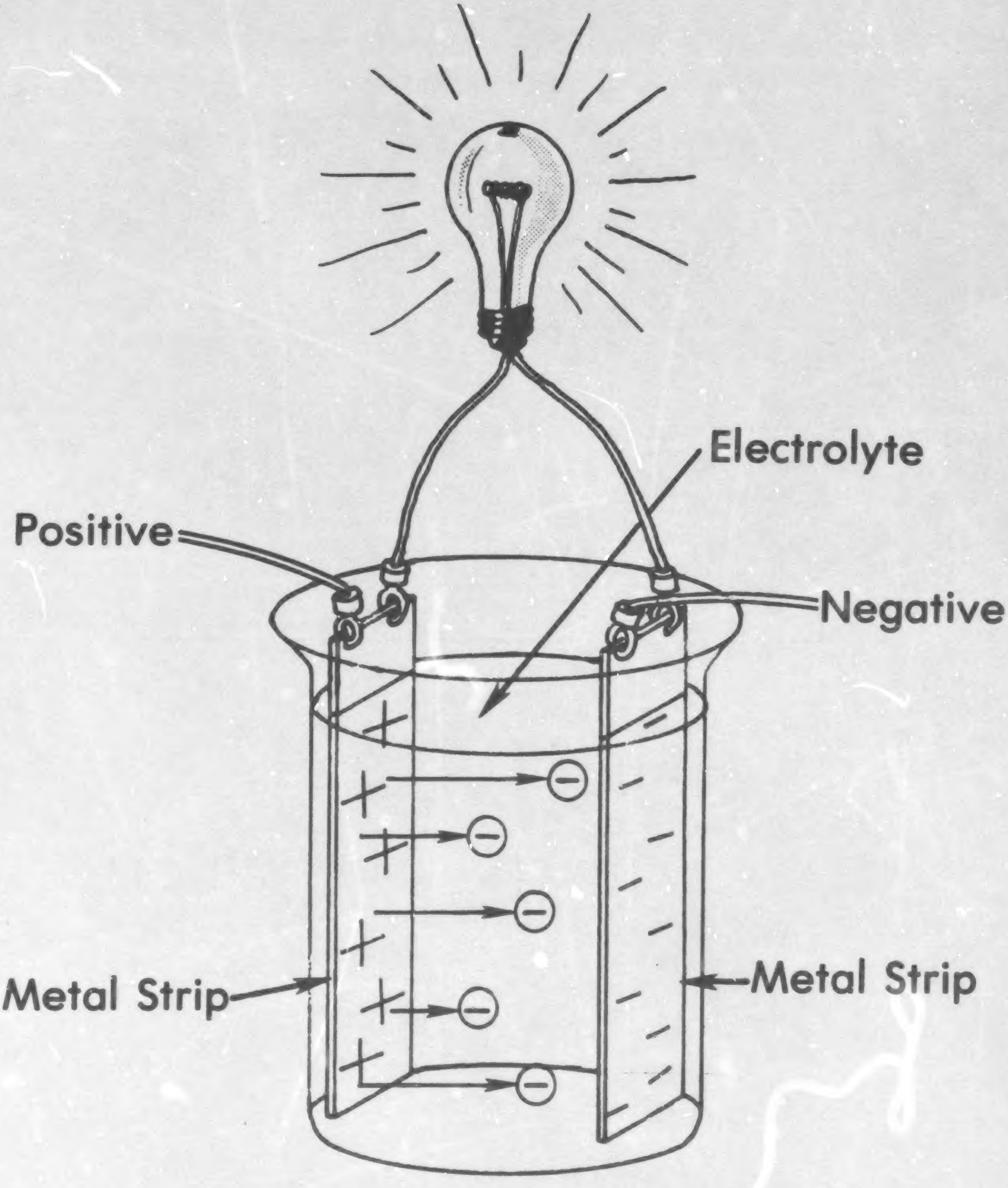

Too many –
Potential Difference
Voltage or
Electromotive
Force
V or E
Not Enough –

Measurement is Volts

Volts measured with a voltmeter

Symbol for volts is V or E

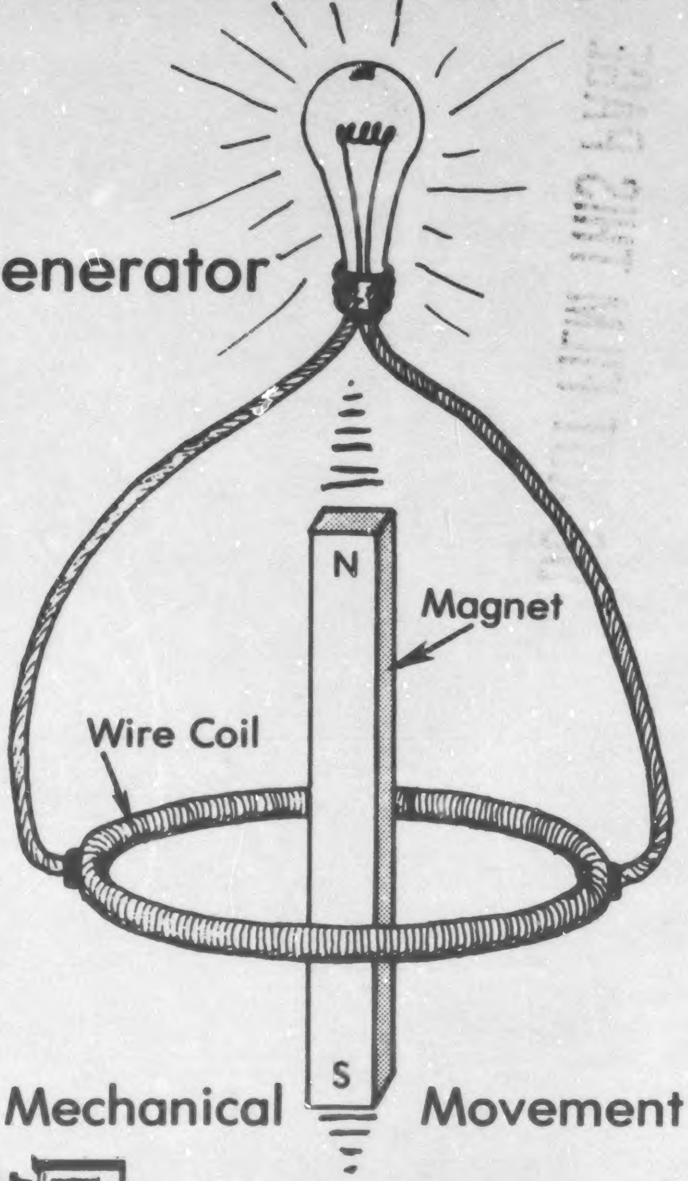
Chemical Action Converted to Electricity


Electrolyte
Positive
Negative
Metal Strip
Metal Strip

1.5V Potential Difference

Mechanical Action Converted to Electricity

Generator


Magnet
N
Wire Coil
S
Mechanical
Movement

Piezoelectric

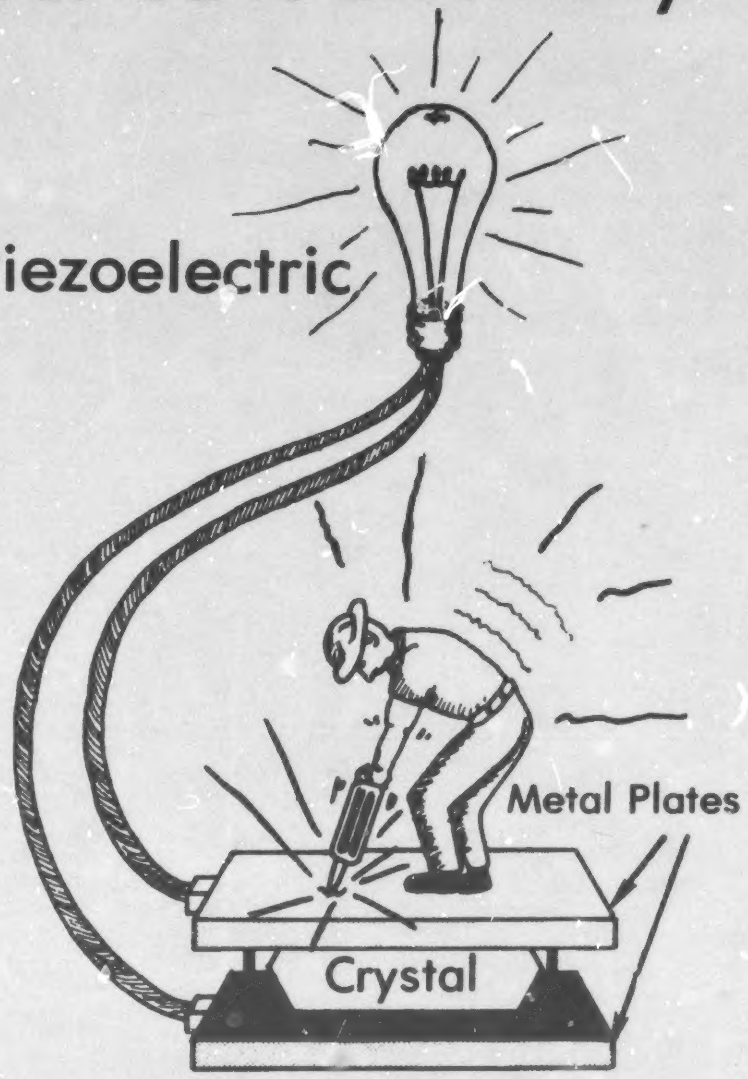

Metal Plates
Crystal
Vibration or Stress

Fig. 50

ELECTRICITY

III-A-1a(AS)
Key

Name________________________ Date______________________

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

Mass — 1. Matter is anything that occupies space and has ____.

Atom — 2. The ____ is the basic unit of any substance.

Electrons — 3. An atom consists of a nucleus with one or more ____ in orbit.

Protons — 4. The nucleus contains one or more ____ and usually one or more neutrons.

Ion — 5. An atom with a positive or negative charge is called a/an ____.

Free — 6. Electrons that can move from one atom to another are called ____ electrons.

Conductors — 7. A material that has many free electrons is called a/an ____.

Insulators — 8. A material that has few free electrons is called a/an ____.

Conductors — 9. To provide a path for electric current, ____ are used.

Current — 10. The flow of electrons is called an electric ____.

Static — 11. The excess or deficiency of free electrons on an object is called ____ electricity.

Friction — 12. The usual cause of static electricity is ____.

Repel — 13. When like charges are brought near each other, they tend to ____ each other.

Attract — 14. When unlike charges are brought near each other, they tend to ____ each other.

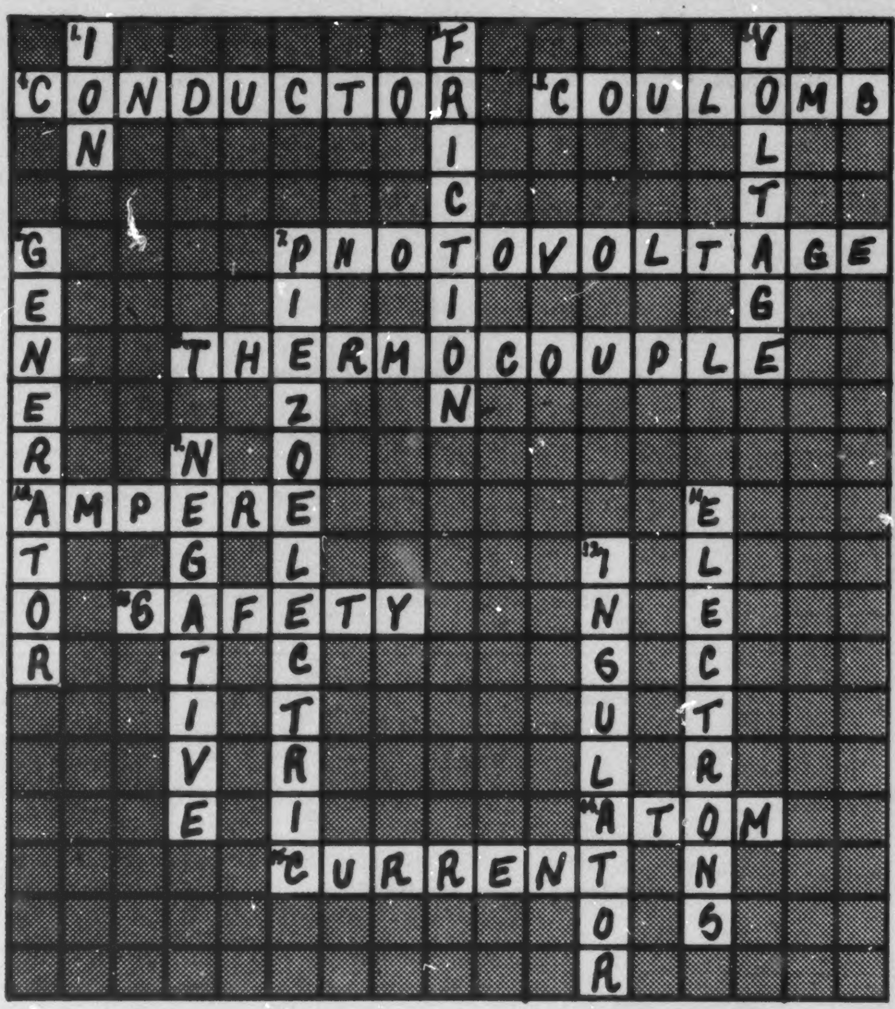
Coulomb — 15. The unit of measurement for the quantity of electrical charge is the ____.

Electromotive	16. Voltage is also called difference of potential, electrical pressure and ____ force.
E	17. The letter symbol for potential difference is ____.
Volt	18. The unit of measure for potential difference is the ____.
Ampere	19. The unit of measure for current flow is the ____.
I	20. The letter sumbol for current flow is ____.
6.28 x 10^{18}	21. By adding ____ electrons to an object, a one coulomb charge is obtained.
Positive	22. The direction of current flow in a circuit is toward the more ____ terminal of the voltage source.
Voltaic Cell	23. A/an ____ is a chemical source of electricity, made up of two dissimilar metal strips placed in an acid solution.
Piezoelectric	24. A/an ____ device is a crystal material such as quartz that generates a voltage when it is subjected to mechanical stress.
Solar Cell	25. A photovoltaic or ____ converts light energy into electrical energy.
Thermocouple	26. A/an ____ consists of two different kinds of metals joined at a junction. When heated, a voltage is present across the junction.
Generator	27. A/an ____ is a machine that converts mechanical energy into electrical energy.
1.5	28. A dry cell produces approximately ____ volts.
Chemical	29. Voltaic cells are classified as a/an ____ source of electricity.
Acid	30. For safety, storage batteries must be handled carefully because they contain liquid ____.

ELECTRICITY TERMS

III-A-1b (AS)
Key

Name______________________________ Date ___________________________



	1 I							2 F						3 V		
4 C	O	N	D	U	C	T	O	R		5 C	O	U	L	O	M	B
	N							I						L		
								C						T		
6 G					7 P	H	O	T	O	V	O	L	T	A	G	E
E					I			I						G		
N			8 T	H	E	R	M	O	C	O	U	P	L	E		
E					Z			N								
R			9 N		O											
10 A	M	P	E	R	E								11 E			
T			G		L						12 I		L			
O		13 S	A	F	E	T	Y				N		E			
R			T		C						S		C			
			I		T						U		T			
			V		R						L		R			
			E		I						14 A	T	O	M		
					15 C	U	R	R	E	N	T		N			
											O		S			
											R					

ACROSS CLUES:
4. Many Free Electrons
5. Unit of Electrical Charge
7. Solar Cell
8. Converts Heat to Electrical Energy
10. Unit for Current
13. Careful Handling of Batteries
14. Basic Unit of Any Substance
15. Flow of Electrons

DOWN CLUES:
1. Charged Atom
2. Usual Cause of Static Electricity
3. Potential Difference
6. Converts Mechanical to Electrical Energy
7. Quartz Crystal
9. Current Flows from ___ to Positive
11. Orbit the Nucleus
12. Rubber, Glass, and Mica

TEST

Name ____________________ Date ____________________

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

Nucleus 1. The ____ contains one or more protons and usually one or more neutrons as well.

Electron 2. A/an ____ is a negatively charged particle that forms the outside part of an atom.

Ion 3. An atom with negative charge is called a negative ____.

Current 4. The flow of electrons is called an electric ____.

Free 5. An electron that can move from one atom to another is called a/an ____ electron .

Many 6. A material that has ____ free electrons is called a conductor.

Few 7. A material that has ____ free electrons is called an insulator.

Friction 8. The usual cause of static electricity is ____.

Like 9. When ____ charges are brought near each other, they tend to repel each other.

Electromotive 10. The pressure that causes current flow is called voltage, difference of potential or ____ force.

Coulomb 11. A negative one ____ charge can be obtained by adding 6.25×10^{18} electrons to an object.

Negative 12. The direction of current flow in a circuit is from the more ____ terminal of the voltage source.

Safety 13. For ____, eye protection should be worn when handling storage batteries.

1.5 14. A dry cell produces approximately ____ volts.

Directions: Match the terms in column A with the terms in column B. Write the letter representing the correct answer in the space provided. Be sure to check your answers.

	Column A	Column B
F	15. Difference of Potential	A. Friction
H	16. Electron Flow	B. Heat
A	17. Static Electricity	C. Mechanical
K	18. Coulombs per Second	D. Q
B	19. Thermocouple	E. Chemical
E	20. Voltaic Cell	F. EMF
J	21. Piezoelectric	G. Negative
C	22. Generator	H. Current
D	23. Charge	I. Nucleus
G	24. Electrons	J. Quartz
I	25. Protons	K. Ampere

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Resistance
AIM:	Upon successful completion of the lesson, the student will be able to identify various types of resistors, interpret the E.I.A. Color Code, measure resistance, relate to the determining factors of resistance, and select a resistor for a specific circuit need.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500 figs. 51-52, resistor boards
MATERIALS:	Information Sheet - E.I.A. Color Code Assignment Sheet - E.I.A. Color Code Assignment Sheet - Resistance Task Sheet - Resistor Color Code and Measurement Test Sheet - Resistance
TOOLS AND EQUIPMENT:	Student lab station, component set, VOM
REFERENCES:	Fowler, Electricity - Principles and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Electronic circuits have many resistors of different values and types in them. What is a resistor? Many of these resistors are color coded. What do these colors mean? Why so many different types of resistors? In this lesson you will learn to identify the various types of resistors and how to determine the value from the color code. You will also learn what determines the resistance of a resistor and how to select the proper type for a specific purpose in a circuit. In a previous lesson you learned to use a VOM to measure voltage and current. In this lesson, you will learn to use it to measure resistance.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Resistance Show Transparency fig. 51	1. Ability of a material to oppose current flow 2. Silver and copper have low resistance 3. Nichrome (Nickel Chromium) has high resistance 4. Letter symbol: R

5. Unit: Ohm, Ω (Greek letter omega)
6. Factors which determine resistance
   - a. Resistivity - a property of the material
   - b. Length - the longer the path for current, the more resistance
   - c. Cross-sectional area - thicker or larger diameter piece of material, less resistance
   - d. Temperature - resistance changes as the temperature changes
   - e. Formula: $R = \mu 1T/A$

B. Conductance

1. The ability of a circuit to conduct current
2. High conductance = low resistance
3. Letter symbol: G
4. Unit: Mho, ℧
5. Formula: $G = 1/R$

C. Resistor uses

1. Limit or control current flow
2. Dissipate heat
3. Produce light (incandescent lamp)

D. Resistor types

1. Fixed
   - a. Carbon composition - compressed graphite with an insulating covering
   - b. Carbon film - graphite coating on substrate
   - c. Metal film - metal coating on substrate. Accurate values
   - d. Wire wound - nichrome wire wrapped around support. High power ratings
2. Variable
   - a. Potentiometer
     - 1.) Carbon or wire construction
     - 2.) Three terminals
     - 3.) Used to control voltage
       - a.) Taper
         - i.) Linear, non-linear and audio
         - ii.) Describes how resistance changes with shaft rotation
   - b. Rheostat
     - 1.) Wire wound construction
     - 2.) Used to control current
     - 3.) Has two terminals
   - c. Thermistors - vary resistance with changes in temperature
   - d. Photoresistor - vary resistance with changes in light levels

E. Power Rating

1. Physical property depending on construction
2. Amount of power the resistor can dissipate
3. Larger size indicates higher power rating
4. Wire wound have higher ratings

F. E.I.A. Color Code

Show Transparency fig. 52

1. Colors
    - a. Black = 0
    - b. Brown = 1
    - c. Red = 2
    - d. Orange = 3
    - e. Yellow = 4
    - f. Green = 5
    - g. Blue = 6
    - h. Violet = 7
    - i. Gray = 8
    - j. White = 9
    - k. Gold = 0.1 or 5%
    - l. Silver = 0.01 or 10%
2. Resistor band identification
    - a. Band one is next to the end of the resistor
    - b. Turn resistor so this end is on left side
    - c. Bands run in numerical order from left to right
3. Band identification
    - a. 1st band - 1st significant figure of value
    - b. 2nd band - 2nd significant figure of value
    - c. 3rd band - multiplier
    - d. 4th band - tolerance
    - e. 5th band - (if present) reliability
4. Resistance value
    - a. Write number indicated by color of 1st band
    - b. Write number indicated by color of 2nd band
    - c. Multiply by number indicated by color of 3rd band
5. Tolerance
    - a. Determine % tolerance by color of 4th band
    - b. Determine resistance value by color code
    - c. Calculate tolerance (multiply marked value by tolerance percentage)
    - d. Calculate plus range by adding tolerance value to marked value
    - e. Calculate minus range by subtracting tolerance value from marked value

    f. Interpretation -- the actual value is between the plus and minus values
6. Reliability
    a. Amount of change in value after 1,000 hours
    b. Indicated by 5th band if present
    c. Is a percentage of value change (ex: .1%)

G. American Wire Gage

1. As gage numbers increase from 1 to 40, diameter decreases
2. The higher the gage number, the thinner the wire
3. The higher the gage number, the more resistance for a given length

H. Measuring Resistance

1. Set function switch to resistance
2. Connect test leads to meter
3. Zero adjust meter
4. Connect test leads to resistance to be measured

(SAFETY NOTE: BE SURE NO VOLTAGE IS PRESENT IN CIRCUIT)

5. Use the range best suited for the resistance being measured
6. Multiply the meter reading by the range indicated

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Resistance
2. Assignment Sheet - E.I.A. Color Code
3. Task Sheet - Resistor Color Code and Measurement

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

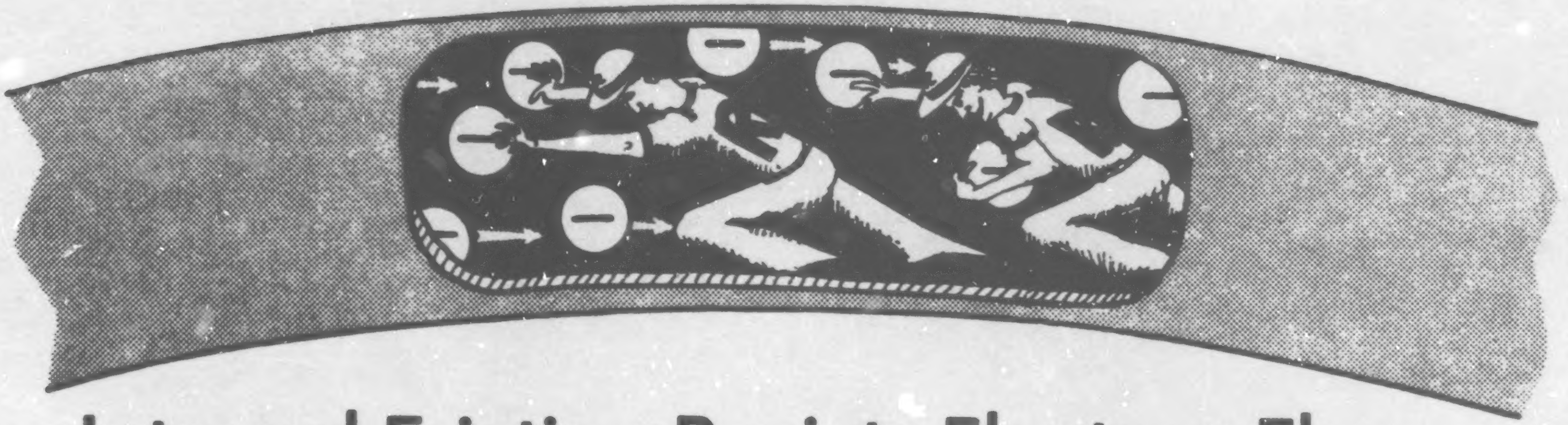
1. Ask oral questions
2. Test Sheet - Resistance
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Ohm's law and power

RESISTANCE

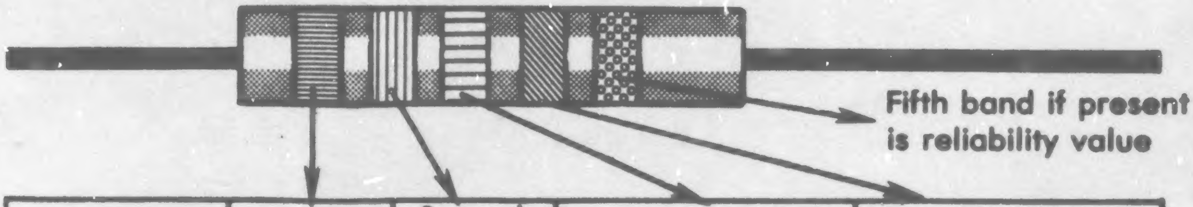


Internal Friction Resists Electron Flow

- * Measured in OHMS
- * OHMS measured with ohmmeter
- * Symbol for OHMS is R

COLOR CODE

PROPER RESISTOR POSITION


Fifth band if present is reliability value

Color	First Band	Second Band	Third Band	Fourth Band
	1st Significant Value	2nd Significant Value	Multiplier	Tolerance (per cent)
Black	0	0	1	
Brown	1	1	10	1
Red	2	2	100	2
Orange	3	3	1,000	3
Yellow	4	4	10,000	4
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	100,000,000	
White	9	9	1,000,000,000	
Gold			0.1	5
Silver			0.01	10
none				20

Big Bulls Romp On Yon Green But Violet Goes Waving

Fig. 52

EIA COLOR CODE

III-B-1a(AS)
Key

					[1] B						
					R		[2] B	L	A	C	K
		[3] V			O		L				
		I			W		U				
		[4] O	R	A	N	G	E				
		L									
[5] G	R	E	E	N							
R		T									
A											
[6] Y	E	L	L	O	[7] W						
					H						
			[8] G		I						
			O		T						
	[9] S	I	L	V	E	[10] R					
			D			E					
						D					

ACROSS CLUES:
2. Zero
4. Three
5. Five
6. Four
9. 10%

DOWN CLUES:
1. One
2. Six
3. Seven
5. Eight
7. Nine
8. 5%
10. Two

RESISTANCE

III-B-1b (AS)
Key

Name ____________________ Date ____________________

Directions: Each student is to complete this assignment sheet on an individual basis. Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

Oppose 1. Resistance is the ability of a material to ____ the flow of electric current.

Ohm 2. The unit of measurement for resistance is the ____.

Conductance 3. The ability of a material to conduct electricity is called ____.

Power 4. It takes electrical ____ to get current to flow through a resistance.

Heat 5. Resistors dissipate energy in the form of ____.

Nichrome 6. Heating elements are constructed using ____ wire because of its high resistance.

Carbon 7. Most resistors are constructed using powdered ____ or high resistance wire.

Potentiometer 8. A variable resistor called a ____ is used to vary voltage in a circuit.

Rheostat 9. A variable resistor called a ____ is used to vary the current flow in a circuit.

Linear 10. A/an ____ taper control changes proportionally with the shaft rotation.

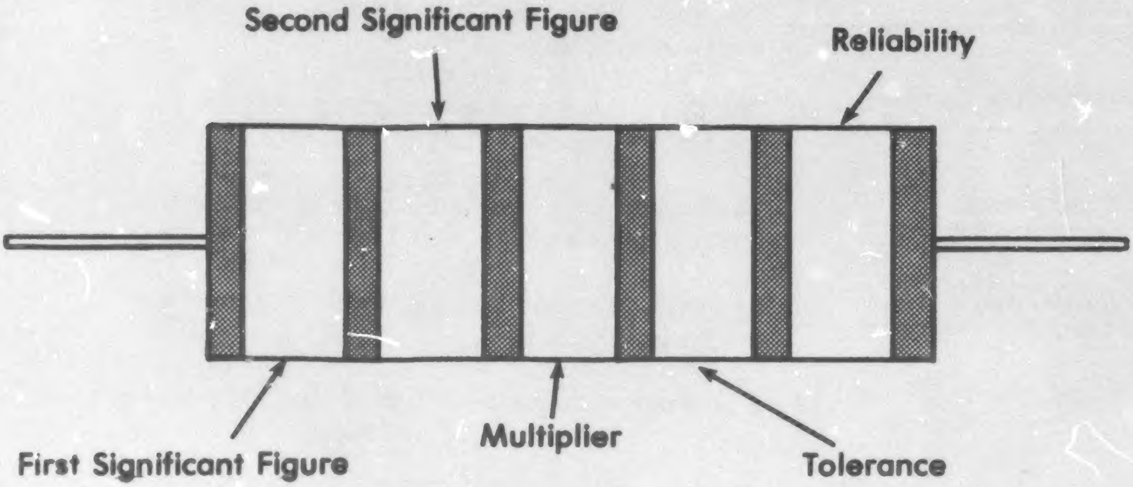
Physical 11. The ____ size of a resistor determines its power rating.

Resistivity 12. The factors that determine the resistance of a material are the cross-sectional area, length, temperature and the ____ of the material.

More 13. The larger the gage number of a wire, the ____ resistance it has for a given length.

1st Sig Figure	14. The first color band on a resistor indicates the ____ of the resistor value.
2nd Sig Figure	15. The second color band on a resistor indicates the ____ of the resistor value.
Multiplier	16. The third color band on a resistor indicates the ____ of the resistor value.
Tolerance	17. The fourth color band on a resistor indicates the ____ of the resistor value.
Reliability	18. The fifth color band on a resistor indicates the ____ of the resistor value.
89 M Ohm 10%	19. A resistor with the color bands gray, white, blue and silver is what value and tolerance?
22 K Ohm 5%	20. A resistor with the color bands red, red, orange, and gold is what value and tolerance?
16 Ohm 10%	21. A resistor with the color bands brown, blue, black and silver is what value and tolerance?
5.4 Ohm 10%	22. A resistor with the color bands green, yellow, gold and silver is what value and tolerance?
950 - 1050	23. A one Kilo Ohm resistor with a 5% tolerance will have an actual value between ____ and ____.
Voltage	24. Care must be taken when measuring resistance to be sure there is no ____ present in the circuit.
Zero Adjust	25. Be sure to ____ an ohmmeter each time it is used to insure more accurate readings.

ELECTRONIC INDUSTRIES ASSOCIATION RESISTOR COLOR CODE


Second Significant Figure
Reliability
First Significant Figure
Multiplier
Tolerance

Color	Significant Figures	Multiplier	Tolerance	Reliability (per 1,000)
Black	0	x 10^0		
Brown	1	x 10^1		1%
Red	2	x 10^2		0.1%
Orange	3	x 10^3		0.01%
Yellow	4	x 10^4		0.001%
Green	5	x 10^5		
Blue	6	x 10^6		
Violet	7	x 10^7		
Gray	8	x 10^8		
White	9	x 10^9		
Gold		x 10^{-1}	5%	
Silver		x 10^{-2}	10%	
None			20%	

RESISTOR COLOR CODE AND MEASUREMENT

III-B-1(TS)

Name ______________________________ **Date** ______________________________

Directions:

1. Record in the chart below the color of each color band on the numbered resistors.
2. Interpret the color code for the marked value and tolerance and record in the space provided.
3. Calculate the range and record in the space provided.
4. Measure the resistors using the VOM and record the measured value in the space provided.
5. If you have any questions, ask your instructor.

#	1st Color Band	2nd Color Band	3rd Color Band	4th Color Band	Marked Value and Tolerance	Range Low to High	Measured Value
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

TEST

III-B-1(T)
Key

Name ____________________ Date ____________________

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

Power	1. It takes electrical ____ to get current to flow through a resistance.
Heat	2. Resistors dissipate energy in the form of ____.
Conductance	3. The ability of a material to conduct electricity is called ____.
Oppose	4. Resistance is the ability of a material to ____ the flow of electric current.
Nichrome	5. Heating elements are constructed using ____ wire because of its high resistance.
Potentiometer	6. A variable resistor called a ____ is used to vary voltage in a circuit.
More	7. The larger the gage number of a wire, the ____ resistance it has for a given length.
False	8. Metal film resistors are made to dissipate greater than 3 watts of power. (true or false)
Reliability	9. The fifth color band on a resistor indicates the ____ of the resistor.
Voltage	10. Care must be taken when measuring resistance to be sure there is no ____ present in the circuit.
True	11. The physical size of a resistor is an indication of its power rating. (true or false)
Friction	12. As electrons move through a material, heat is produced by ____ as they rub against each other.
Smaller	13. The smaller the American Wire Gage number, the ____ the resistance.
Linear	14. A/an ____ taper control changes proportionally with the shaft rotation.

Zero Adjust 15. Be sure to ____ an ohmmeter each time it is used to insure more accurate readings.

Directions: Complete the following table for the ten resistors on the resistor test board. The first five (R1 to R5) are color coded. Record their marked values and tolerance. The second five (R6 to R10) are not color coded. Measure and record their values.

R1________________ 16.

R2________________ 17.

R3________________ 18.

R4________________ 19.

R5________________ 20.

R6________________ 21.

R7________________ 22.

R8________________ 23.

R9________________ 24.

R10________________ 25.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Ohm's Law and Power
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate an understanding of the relationship between voltage, current, resistance and power by constructing simple circuits, making circuit measurements and making Ohm's law and power calculations.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, fig. 53-55
MATERIALS:	Information Sheet - Electric Meter Reading Assignment Sheet - Ohm's Law Assignment Sheet - Power Experiment #6 - Ohm's Law Experiment #7 - Power - Heat - Light Test Sheet - Ohm's Law and Power
TOOLS AND EQUIPMENT:	Student lab station, component set
REFERENCES:	Fowler, Electricity - Principles and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Did you know that voltage, current, resistance and power are related to each other? A German physicist by the name of Georg Simon Ohm did a study of a direct current circuit and developed a law and a mathematical formula to prove the law. Of all the natural laws associated with electricity, the most widely used is Ohm's Law, which defines the relationship between voltage, current and resistance. An understanding of this relationship is necessary before you can understand many of the other concepts of electronics. In this lesson, you will also learn what power is and how it fits into the relationship with voltage, current and resistance. It is important to understand power to keep from damaging components. This knowledge will greatly help you in your job as an electronics technician.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Ohm's Law	1. Relationship between voltage current and resistance in an electrical circuit

Show Transparency fig. 53

2. A potential difference of 1 Volt will cause a current flow of 1 Ampere through a resistance of 1 Ohm
3. Formulas
    a. $E = I \times R$
    b. $I = E / R$
    c. $R = E / I$

B. Relationships

1. Voltage is directly proportional to current or resistance
2. Current is directly proportional to voltage and inversely to resistance
3. Resistance is directly proportional to voltage and inversely to current

C. Calculations

1. Solve for voltage
    a. I = 2 A R = 10 Ohms E = __ (20V)
    b. I = 2 A R = 3 Ohms E = __ (6V)
    c. I = 0.2 A R = 4 Ohms E = __ (0.8 V)
    d. I = 0.02 A R = 100 Ohms E = __ (2 V)
2. Solve for current
    a. E = 20 V R = 10 Ohms I = __ (2A)
    b. E = 0.8 V R = 4 Ohms I = __ (300mA)
    c. E = 6V R = 3 Ohms I = __ (2A)
    d. E = 3 V R = 100 Ohms I = __ (30mA)
3. Solve for resistance
    a. E = 20V I = 2A R = __ (10 Ohms)
    b. E = 6V I = 2A R = __ (3 Ohms)
    c. E = 0.8 V I = 200mA R = __ (4 Ohms)
    d. E = 3V I = 30mA R = __ (100 Ohms)

D. Power

Show Transparency fig. 54

1. Power is the rate of doing work
2. Power is the rate of producing or using electrical energy
3. Symbol: P
4. Unit: Watt, W
5. Formulas
    a. $P = I \times E$
    b. $P = I^2 \times R$
    c. $P = E^2 / R$
6. Current and voltage are directly proportional to power

E. Calculations

Show Transparency fig. 55

1. I = 2 A E = 2 V P = __ (4W)
2. I = 10 mA E = 10 V P = __ (100 mW)
3. I = 100 mA E = 20 V P = __ (2 W)
4. I = 25 mA E = 5 V P = __ (125 W)
5. I = 3 A E = 2 V P = __ (6 W)

F. Watt Hour Meters Use Information Sheet	1. Measures electrical power consumption 2. Reading meter a. Start at left dial and go to right b. Meter may have 4 or 5 dials c. Put down the last number the hand has passed d. Subtract starting meter reading from ending meter reading to determine amount used during period

---

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Ohm's Law
2. Experiment #6 - Ohm's Law
3. Assignment Sheet - Power
4. Experiment # 7 - Power - Heat - Light
5. Check each student's work for completeness and accuracy
6. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - Ohm's Law and Power
3. 70% correct is required for satisfactory completion of the lesson

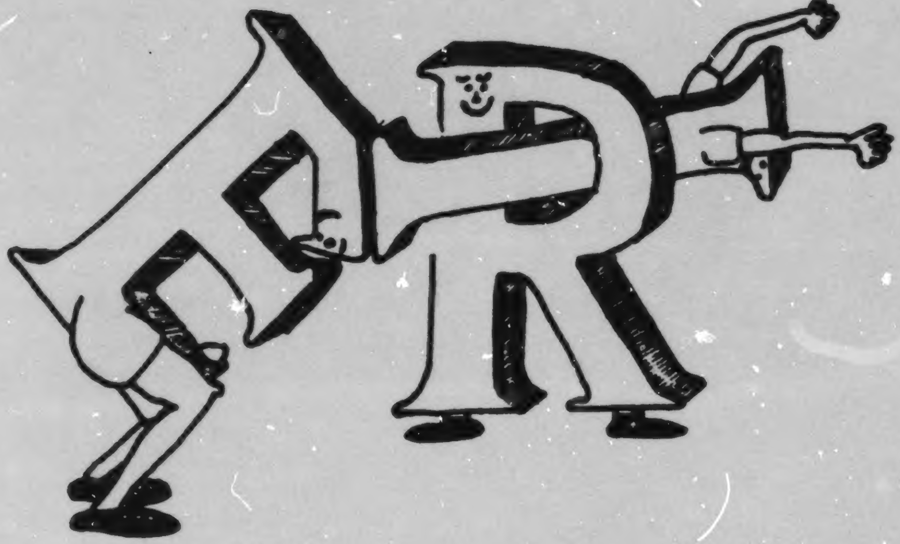
---

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Series Resistive Circuits

Ohm's Law



☐

One volt (E) will push one amp (I) through one ohm (R) resistance.

☐

E = IR   Volts = Amperes x Ohms

POWER

Definition: Rate of doing work (w/t)

❑

Symbolized by 'P'

❑

May be calculated with formulas

$P = IE$ $P = I^2R$ $P = E^2/R$ Watt's Law

❑

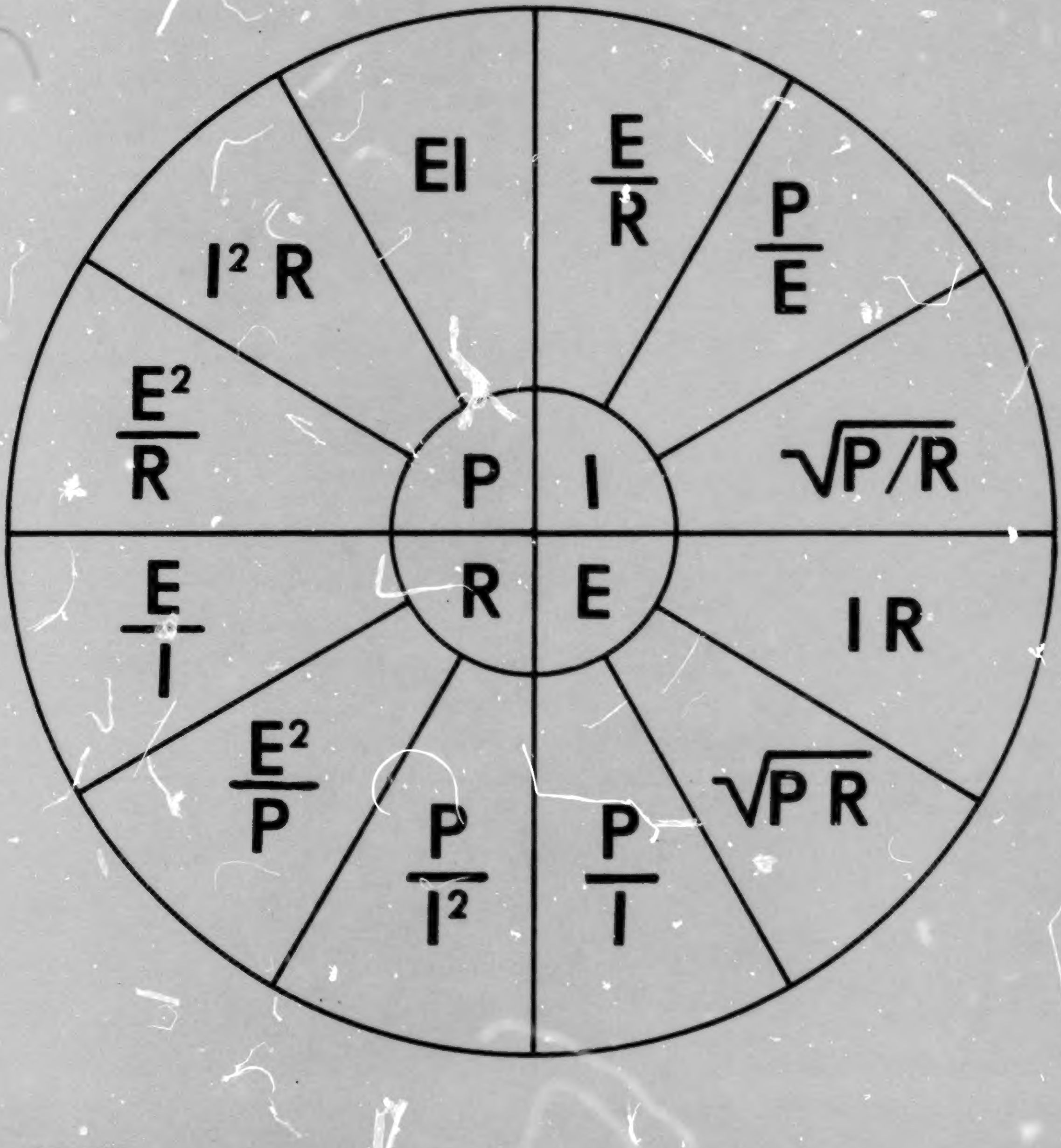
Unit of measure is watt

1 watt = 1 ampere x 1 volt

❑

Wattmeter used to measure

MEMORY WHEEL


P
I
R
E
EI
$\frac{E}{R}$
$\frac{P}{E}$
$\sqrt{P/R}$
IR
$\sqrt{PR}$
$\frac{P}{I}$
$\frac{P}{I^2}$
$\frac{E^2}{P}$
$\frac{E}{I}$
$\frac{E^2}{R}$
I^2R

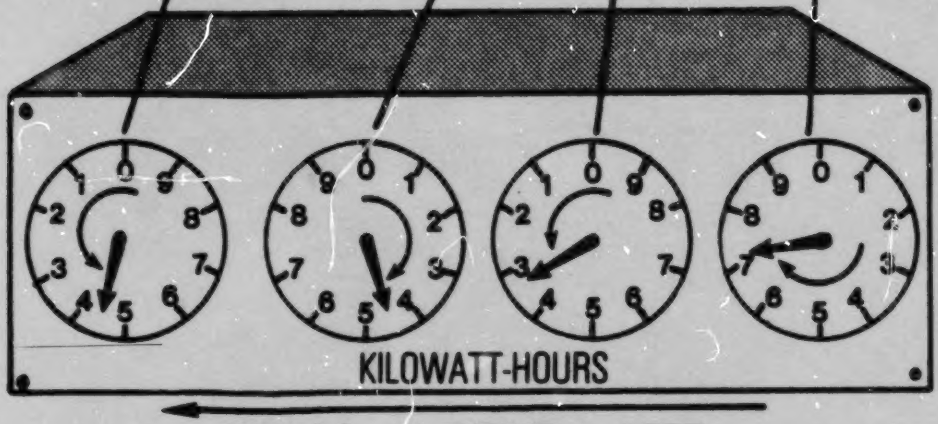
POINTER-REGISTERS ARE READ FROM RIGHT TO LEFT

(A) Record last number passed by pointer - 7

(B) Record last number passed on second dial - 37

(C) Record last number passed on third dial - 437

(D) Record last number passed on fourth dial - 4437


1
0
9
2
8
3
7
4
5
6
9
0
1
8
2
7
3
6
5
4
1
0
9
2
8
3
7
4
5
6
9
0
1
8
2
7
3
6
5
4
KILOWATT-HOURS

Read from RIGHT to LEFT

OHM'S LAW

III-C-1a(AS)
Key

Name ______________________ Date ______________________

Directions: Use Ohm's Law to complete the statements and solve for unknown values. Round off your answers to three significant figures and write them in the spaces provided using the proper metric prefix. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

E = I x R	1. The Ohm's Law formula for voltage is ____.
Double	2. If the voltage in a circuit is doubled and the resistance remains the same, the current will ____.
Double	3. If the voltage in a circuit remains the same and the resistance is divided in half, the current will ____.
Half	4. If the resistance in a circuit doubles and the voltage remains the same, the current will be ____.
4.00 A	5. A circuit has 120 V applied across 30 Ohms of resistance; the current will be ____.
50.0 V	6. A device that requires 5 A and has a resistance of 10 Ohms must be connected across ____ Volts.
25.0 Ohms	7. A device that has a voltage drop of 100 V across it when 4 A of current is flowing through it has a resistance of ____.
12.0 V	8. A lamp has a resistance of 40 Ohms and requires 300 mA of current for proper operation. It must be connected to a voltage source of ____.
1.09 A	9. A light bulb has a resistance of 110 Ohms. A current of ____ will flow through it when connected to 120 V.
100 Ohms	10. Calculate the resistance of the filament of a lamp if the current is 0.06 A when applied voltage is 6V.
20.0 V	11. I = 2.00 A R = 10.0 Ohms E = ____
50.0 V	12. I = 0.20 A R = 250 Ohms E = ____
75.0 V	13. I = 3.00 mA R = 25.0 KOhms E = ____
750 V	14. I = 250 mA R = 3.00 KOhm E = ____

1.00 KV 15. I = 100 mA R = 10 KOhms E = ____

10.0 KV 16. I = 1.00 mA R = 10 MOhms E = ____

140 mV 17. I = 2 mA R = 70 Ohms E = ____

2.00 A 18. E = 20 V R = 10 Ohms I = ____

200 mA 19. E = 50 V R = 250 Ohms I = ____

3.00 mA 20. E = 75 V R = 25 Ohms I = ____

1.00 mA 21. E = 10 V R = 10.0 KOhms I = ____

1.00 uA 22. E = 10 V R = 10 MOhms I = ____

25.0 mA 23. E = 75 V R = 3 KOhms I = ____

100 uA 24. E = 1.00 V R = 10 KOhms I = ____

500 Ohms 25. E = 10.0 V I = 20 mA R = ____

55.0 Ohms 26. E = 110 V I = 2.00 A R = ____

10.0 KOhm 27. E = 10 V I = 1.00 mA R = ____

5.00 KOhm 28. E = 15 V I = 3.00 mA R = ____

10.0 KOhm 29. E = 1.00 KV I = 100 mA R = ____

750 KOhm 30. E = 750 V I = 1.00 mA R = ____

100 KOhm 31. E = 1.00 KV I = 10.0 mA R = ____

552 mV 32. I = 48.0 uA R = 11.5 KOhm E = ____

714 Ohms 33. E = 25.0 mV I = 35.0 uA R = ____

305 mA 34. E = 82.3 V R = 270 Ohms I = ____

144 uA 35. I = 12.0 uA R = 12 Ohms E = ____

558 uA 36. R = 86 KOhm E = 48 V I = ____

20.5 uA 37. R = 1.2 MOhm E = 24.6 V I = ____

108 mA 38. E = 731 V R = 6.8 KOhms I = ____

128 mA 39. R = 4.7 KOhm E = 600 V I = ____

45.3 uA 40. E = 68 mV R = 1.5 KOhm I = ____

281 uA 41. E = 759 mV R = 2.7 KOhm I = ____

10.5 Ohm 42. I = 393 mA E= 4.14 V R = ____

2.46 KV 43. I = 440 mA R = 5.6 KOhm E = ____

60.0 mA 44. E = 1.20 mV R = 0.02 Ohm I = ____

1.00 KOhm 45. E = 100 V I = 100 mA R = ____

135 V 46. I = 3.00 A R = 45.0 Ohms E = ____

100 Ohms 47. E = 10.0 V I = 100 mA R = ____

6.00 A 48. E = 150 V R = 25.0 Ohms I = ____

780 mA 49. E = 117 V R = 150 Ohms I = ____

10.0 KV 50. I = 5.00 mA R = 2.00 MOhm E = ____

POWER FORMULAS

III-C-1b (AS)
Key

Name ______________________ Date ______________________

Directions: Use the power formulas to solve for the unknown values. Show all work on a work sheet. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

$P = I \times E$ — 1. The formula for power in terms of voltage and current is ____.

$P = I^2 \times R$ — 2. The formula for power in terms of current and resistance is ____.

$P = E^2 / R$ — 3. The formula for power in terms of voltage and resistance is ____.

30.0 mW — 4. If 0.2 mA of current flows in a circuit with 150 V applied, the power dissipated is ____.

5.00 W — 5. When 10 V is applied across a 20 Ohm resistor, the power supplied by the source is ____.

9.99 W — 6. What is the power dissipated by a 25 Ohm lamp that has 632 mA flowing through it?

1.58 A — 7. A radio uses 190 W from the 120 V power source. The receiver draws ___ of current.

5.00 A — 8. What is the current through a 1.25 KW electric heater if the resistance is 50 Ohms?

Increase — 9. If the resistance in a circuit remains constant and the current increases, the power will ____.

1.00 Ohm — 10. If a circuit dissipates 1 W of power when 1 V is applied, the circuit resistance is ____.

50.0 mW — 11. E = 50.0 V I = 1.00 mA P = ____

280 mW — 12. E = 40.0 V I = 7.00 mA P = ____

240 mW — 13. E = 60.0 V I = 4.00 mA P = ____

1.04 W — 14. E = 65.0 V I = 16.0 mA P = ____

160 mW 15. E = 80.0 V I = 2.00 mA P = ____

66.7 mA 16. P = 2.00 W E = 30.0 V I = ____

156 KOhms 17. P = 4.00 mW E = 25.0 V R = ____

80.0 mW 18. R = 5.00 KOhm I = 4.00 ma P = ____

3.33 mW 19. E = 10.0 Volts R = 30.0 KOhms I = ____

5.00 Ohms 20. P = 8.00 mW I = 40.0 mA R = ____

111 V 21. P = 3.00 Watts I = 27.0 mA E = ____

250 V 22. I = 4.00 mA P = 1.00 Watt E = ____

44.0 mA 23. E = 50 Volts P = 2.20 W I = ____

512 mW 24. I = 16.0 mA R = 2.00 KOhms P = ____

338 mW 25. E = 45.0 V R = 6.00 KOhms P = ____

200 W 26. E = 20.0 V R = 2.00 Ohms P = ____

1.09 A 27. P = 240 Watts E = 220 Volts I = ____

360 W 28. R = 90.0 Ohms I = 2.00 A P = ____

625 W 29. I = 12.5 A R = 4.00 Ohms P = ____

20.0 Ohms 30. P = 125 W E = 50.0 Volts R = ____

3.45 mW 31. E = 67.0 V R = 1.30 MOhms P = ____

6.65 W 32. I = 71.5 mA R = 1.30 KOhms P = ____

49.0 V 33. I = 4.08 mA P = 200 mW E = ____

1.47 W 34. I = 23.3 mA E = 63.0 V P = ____

12.5 A 35. P = 875 W E = 70.0 V I = ____

43.9 V 36. I = 3.67 mA P = 161 mW E = ____

371 mW 37. E = 35.0 V I = 10.6 mA P = ____

240 KOhms 38. P = 6.02 mW E = 38.0 V R = ____

24.0 V	39. I = 24.0 A	P = 576 W	E = ____
644 mV	40. R = 4.70 KOhms	E = 55.0 V	P = ____
220 Ohms	41. I = 6.36 mA	P = 8.91 mW	R = ____
3.04 uA	42. R = 5.60 MOhms	P = 51.6 uW	I = ____
774 mW	43. R = 10.0 KOhms	E = 88.0 V	P = ____
93.0 mW	44. I = 8.46 mA	R = 1.30 K Ohm	P = ____
1.61 mA	45. R = 6.20 KOhms	P = 16.1 mW	I = ____
138 mA	46. E = 86.0 V	P = 11.9 W	I = ____
2.88 mW	47. E = 72.0 V	R = 1.80 MOhms	P = ____
43.1 V	48. P = 24.7 mW	I = 573 uA	E = ____
326 uA	49. R = 270 KOhms	P = 28.7 mW	I = ____
645 uW	50. E = 44.0 V	R = 3.00 MOhms	P = ____

TEST

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

A

1. If the current in a circuit remains constant and the resistance increases, the voltage will ____.
   A. increase B. decrease C. remain the same

A

2. If the resistance in a circuit remains constant and the current increases, the voltage will ____.
   A. increase B. decrease C. remain the same

D

3. Power is the ____.
   A. same as electromotive force
   B. number of electrons forced through a resistance
   C. same as conductance
   D. rate of producing or using energy

C

4. Calculate the resistance of a 300 watt light bulb connected across a 120 Volt power line.
   A. 24 Ohms B. 36 KOhms C. 48 Ohms D. 6.9 Ohms

B

5. If a 12 V battery is across a resistance of 6 KOhms, the current flow through the resistance is ____.
   A. 0.2 mA B. 2 mA C. 20 mA D. 2 A

C

6. A potential difference of ____ applied across [illegible] MOhm resistor will produce a current of 1 mA.
   A. 1 uV B. 1 mV C. 1 KV D. 1,000,000 V

C

7. A circuit allows 1 mA of current to flow with 1 V applied. The conductance of the circuit is ____.
   A. 0.001 Ohm B. 0.001 uOhm C. 1,000 uMho D. 1 Mho

B

8. A source of 5 V applied across a resistance of 1,000 Ohms produces a current of ____.
   A. 5 uA B. 5 mA C. 50 mA D. 5 A

D

9. If a current of 200 uA is produced when a source of 30 V is applied, the resistance of the circuit is ____.
   A. 150 Ohms B. 6 KOhms C. 6 MOhms D. 150 KOhms

B 10. A current of ____ will flow in a circuit which has a resistance of 2,500 Ohms connected to a 50 Volt source.

A. 125 A B. 0.02 A C. 200 mA D. 2 mA

Directions: Solve the following circuit problems using Ohm's Law and the power formulas. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers.

1.13 W 11. What is the power dissipated by a 50 Ohm lamp that has 150 mA flowing through it?

1.46 A 12. A computer uses 175 W from the 120 V power source. The computer draws ____ of current.

3.16 A 13. What is the current through a 500 W electric toaster if the resistance is 50 Ohms?

10.0 V 14. If a current of 2 mA passes through a 5 KOhm resistor, the source voltage is ____.

100 mW 15. If the voltage in a circuit is 20 V and the resistance is 4 Kohms, the power will be ____.

18.0 Ohms 16 Calculate the resistance which has 120 V applied across it and is dissipating 800 Watts.

45.0 mA 17. If 4.5 mA of current flows through a 10 Ohm device, the voltage across it equals ____.

200 uA 18. If the voltage in a circuit is 10 V and the power is 2 mW, the current is ____.

4.00 W 19. In a circuit where the source voltage is 20 V and the total circuit current is 200 mA, how much power is being dissipated?

20.0 mW 20. If the voltage in a circuit is 100 Volts and the current is 0.2 mA, the power dissipated is ____.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

IV-A-1(I)

SUBJECT:	Series Resistive Circuits
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate an understanding of the relationship between voltage, current, resistance, and power in a series resistive circuit by constructing circuits, making circuit measurements, and making calculations for values in the circuit.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, figs. 56-58
MATERIALS:	Assignment Sheet - Series Resistive Circuits Assignment Sheet - Series Circuit Analysis Experiment # 8 - Series Circuits - Resistance Experiment # 9 - Series Circuits - Kirchhoff's Law Test - Series Resistive Circuits
TOOLS AND EQUIPMENT:	Student lab station, component set
REFERENCES:	Fowler, Electricity - Principles and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

What is a series circuit? One of the basic circuit configurations used in connecting electronic components is the series circuit. It is important that you have a thorough understanding of this type of circuit. When circuit components are connected end to end, so there is only one path for current to flow, you have a series circuit. In this lesson you will find chances to use the voltmeter, ammeter, and ohmmeter to make circuit measurements. You will also consider the characteristics that apply to series circuits that you will be using in later lessons and in your electronics career.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Circuit Characteristics	1. Series resistive circuits a. Two or more loads b. Components connected end to end 2. Current a. One path for current

b. Current is the same throughout the circuit

c. $I_T = I_1 = I_2 = I_3 \ldots$

3. Resistance

a. Total resistance is equal to the sum of the individual resistances

b. Series resistors could be replaced by one equivalent resistance

c. $R_T = R_1 + R_2 + R_3 \ldots$

4. Voltage

a. Source voltage divides up across the load resistors

b. Voltage drop - voltage across a resistor

c. IR drop - voltage drop across a resistor

d. Polarity of voltage across resistors does not necessarily indicate a deficiency or excess of electrons

e. $E_T = E_1 + E_2 + E_3 \ldots$

5. Power

a. Total power is equal to the sum of the individual power values

b. Power is dissipated by each resistor

c. $P_T = P_1 + P_2 + P_3 \ldots$

B. Kirchhoff's Voltage Law
Show Transparency fig. 56

1. Used for series circuit analysis

2. The sum of the voltage drops around a closed loop must equal zero

3. The sum of the IR drops around a series circuit will equal the source voltage

C. Circuit Analysis
Show Transparency fig. 57

1. Using circuit characteristics

a. $I_T = I_1 = I_2 = I_3 \ldots$

b. $E_T = E_1 + E_2 + E_3 \ldots$

c. $R_T = R_1 + R_2 + R_3 \ldots$

d. $P_T = P_1 + P_2 + P_3 \ldots$

2. Kirchhoff's Voltage Law

a. Use to find source voltage

b. Use to find IR drop across a series resistor

Show Transparency fig. 58

3. Ohm's Law

a. Ohm's Law applies as long as all values are associated with one resistance

b. Example: $R_2 = E_2 / I_2$

4. Short and open circuits
   a. If a component is shorted, the circuit will act as if it is not there
   b. If the circuit is open, all current will stop and the source voltage will be across the open
5. Solve circuit problems using all of the above

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Series Resistive Circuits
2. Assignment Sheet - Series Circuit Analysis
3. Experiment # 8 - Series Circuits - Resistance
4. Experiment # 9 - Series Circuits - Kirchhoff's Law
5. Check each student's work for completeness and accuracy
6. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - Series Resistive Circuits
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Parallel Resistive Circuits

Kirchhoff's Law of Voltage

☆

The sum of the voltage drops around a closed loop always equals zero.

☆

SERIES CIRCUIT CHARACTERISTICS

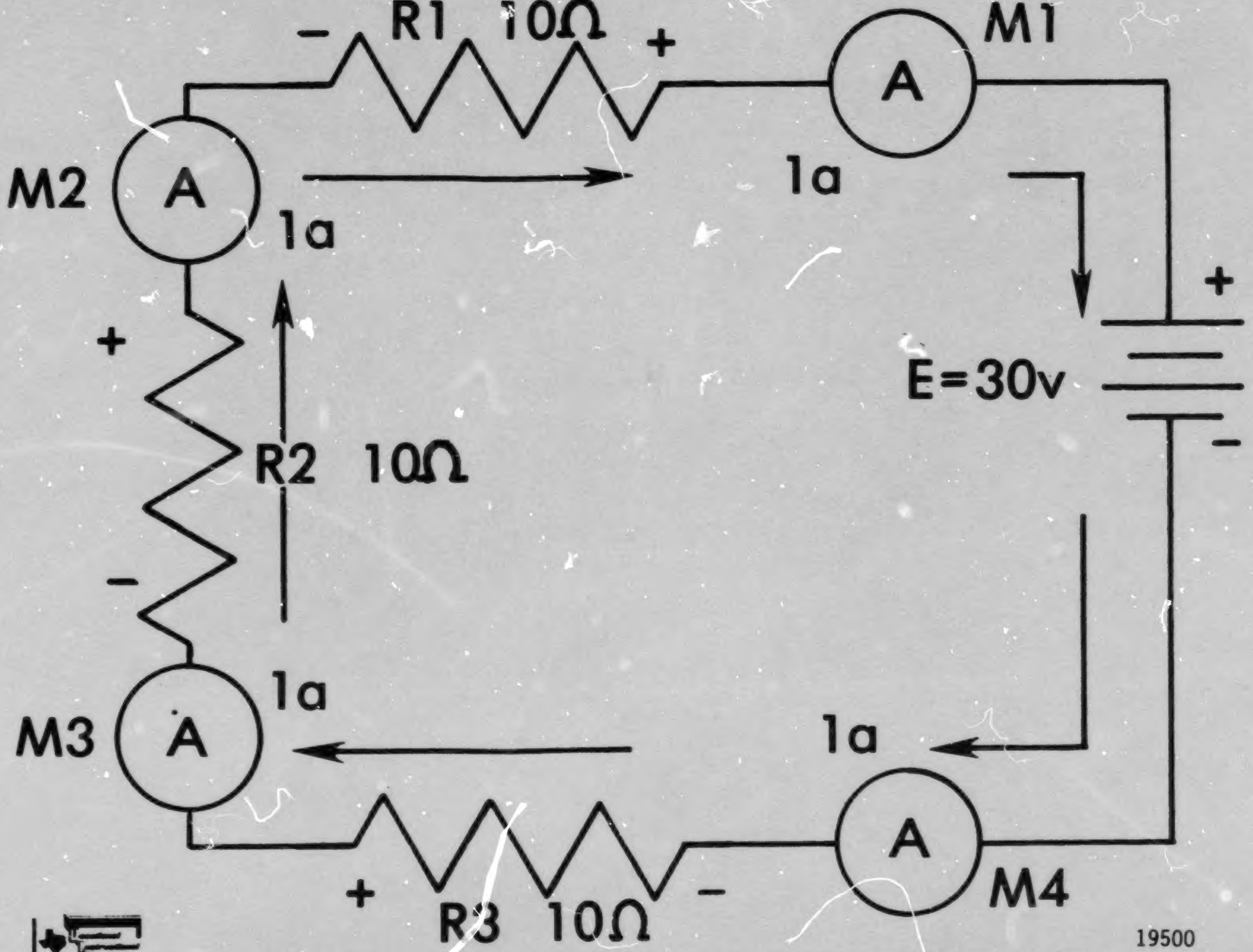
$$E_T = E_1 + E_2 + E_3 \ldots$$

$$I_T = I_1 = I_2 = I_3 \ldots$$

$$R_T = R_1 + R_2 + R_3 \ldots$$

$$P_T = P_1 + P_2 + P_3 \ldots$$

Series Circuit


R1 10Ω
–
+
M1
A
M2
A
1a
1a
+
E=30v
–
R2 10Ω
+
–
1a
M3
A
1a
A
M4
+
R3 10Ω
–

19500 Fig. 58

SERIES RESISTIVE CIRCUITS

IV-A-1a(AS)
Key

Name ______________________________ Date ______________________

Directions: Each student will complete this assignment sheet on an individual basis. Solve the following problems, round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Follow the directions for each section. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

A. Select the word or words which best completes each statement. Place your answer in the space provided. Be sure to check your answers.

$E_T = E_1 + E_2 \ldots$ 1. The voltage characteristic for a series resistive circuit is ____.

$I_T = I_1 = I_2 \ldots$ 2. The current characteristic for a series resistive circuit is ____.

$R_T = R_1 + R_2 \ldots$ 3. The resistive characteristic for a series resistive circuit is ____.

$P_T = P_1 + P_2 \ldots$ 4. The power characteristic for a series resistive circuit is ___.

Source 5. Kirchhoff's Voltage Law states that the sum of the voltage drops around a series circuit equals the ____ voltage.

Current 6. The ____ is always the same at all points in a series circuit.

Higher 7. Resistors connected in series can be used to build ___ values of resistance.

Path 8. When two resistors are connected in series, there is only one ____ for current through the circuit.

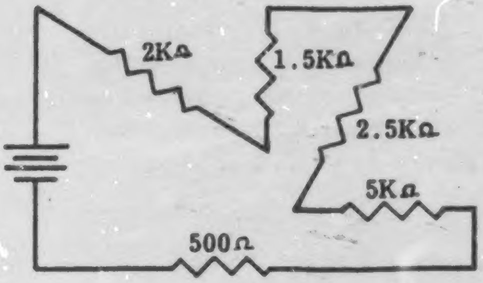
2.00 A 9. With a 4 Ohm and a 2 Ohm resistor connected in series across a 12 Volt battery, the current through each resistor is ____ Amperes.

Sum 10. In a series circuit, the total resistance is equal to the ____ of the series resistors.

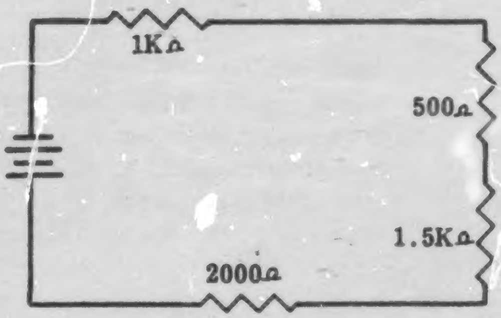
Double 11. If two equal batteries are connected in series aiding, the voltage across both together will be ____ that of each alone.

Current 12. If two lamps are connected in series, they must have the same ____ rating.

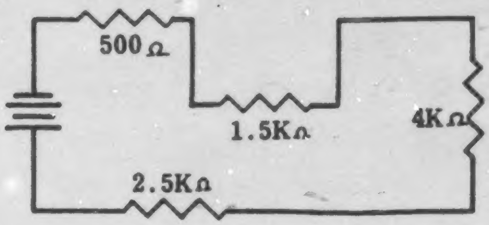
B. Solve for the total resistance in the following circuits. Be sure to check your answers.


2KΩ
1.5KΩ
2.5KΩ
5KΩ
500Ω

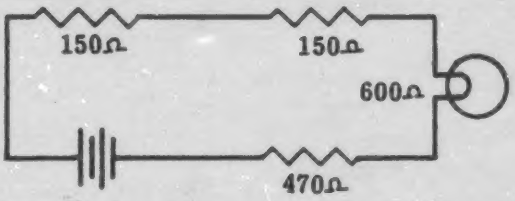
13. 11.5 KΩ


1KΩ
500Ω
1.5KΩ
2000Ω

14. 5.00 KΩ

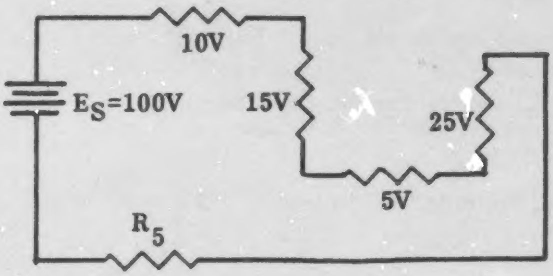

500Ω
1.5KΩ
4KΩ
2.5KΩ

15. 8.50 KΩ

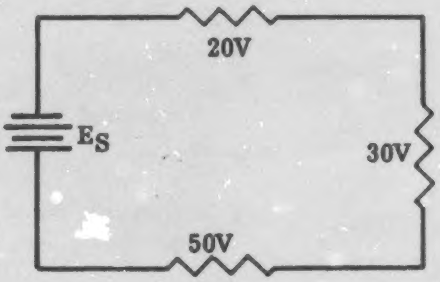

150Ω
150Ω
600Ω
470Ω

16. 1.37 KΩ

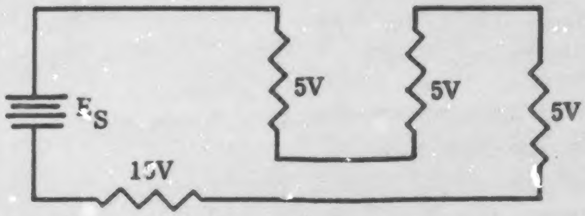
C. Using Kirchhoff's Voltage Law, solve for the indicated voltage value in the following circuits. Be sure to check your answers.


10V
E_S=100V
15V
25V
5V
R_5

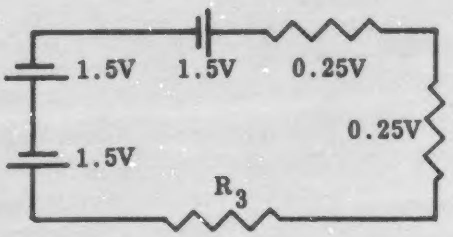
17. E_5 = 45.0 V


20V
E_S
30V
50V

18. E_S = 100 V


E_S
5V
5V
5V
15V

19. E_S = 30.0 V


1.5V
1.5V
0.25V
0.25V
1.5V
R_3

20 E_3 = 1.00 V

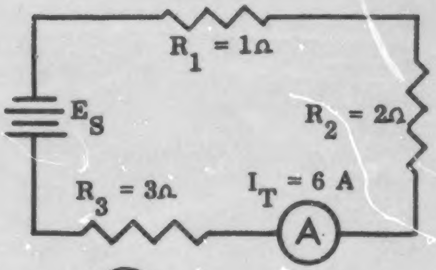
SERIES CIRCUIT ANALYSIS

IV-A-1b (AS)
Key

Name ____________________ Date ____________________

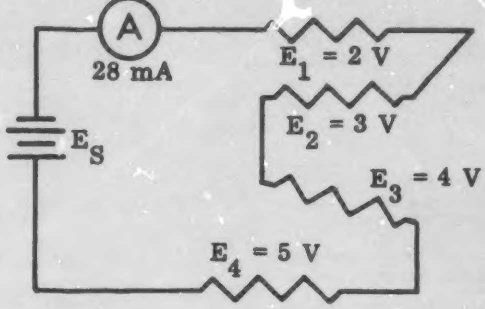
Directions: Each student will complete this assignment sheet on an individual basis. Analyze the following circuits for the values indicated. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

1. E_1 = 6.00 V
2. E_2 = 12.0 V
3. E_3 = 18.0 V
4. E_S = 36.0 V



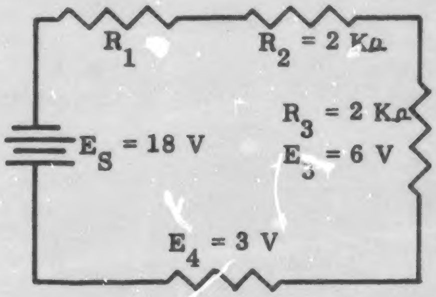
$R_1 = 1\Omega$
E_S
$R_2 = 2\Omega$
$R_3 = 3\Omega$
$I_T = 6$ A
A

5. E_S = 14.0 V
6. R_1 = 71.4Ω
7. R_2 = 107 Ω
8. R_3 = 143Ω
9. R_4 = 179Ω



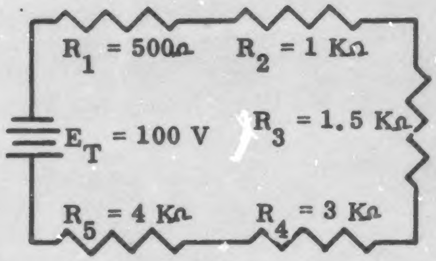
A
28 mA
$E_1 = 2$ V
$E_2 = 3$ V
E_S
$E_3 = 4$ V
$E_4 = 5$ V

10. I_T = 3.00 mA
11. E_1 = 3.00 V
12. R_1 = 1.00 KΩ
13. R_4 = 1.00 KΩ
14. R_T = 6.00 KΩ



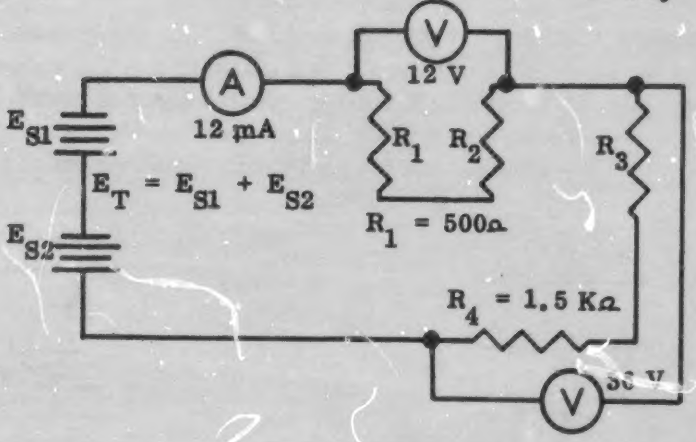
R_1
$R_2 = 2$ KΩ
$R_3 = 2$ KΩ
$E_S = 18$ V
$E_3 = 6$ V
$E_4 = 3$ V

15. I_T = 10.0 mA
16. E_1 = 5.00 V
17. E_2 = 10.0 V
18. E_3 = 15.0 V
19. E_4 = 30.0 V
20. E_5 = 40.0 V



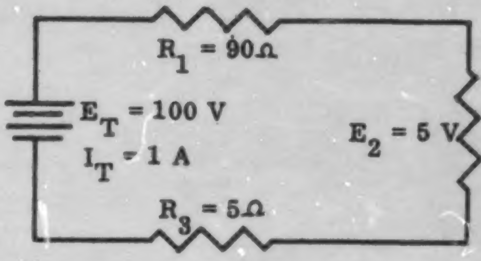
$R_1 = 500\Omega$
$R_2 = 1$ KΩ
$E_T = 100$ V
$R_3 = 1.5$ KΩ
$R_5 = 4$ KΩ
$R_4 = 3$ KΩ

21. R_2 = 500Ω
22. R_3 = 1.50 KΩ
23. E_2 = 6.00 V
24. E_T = 48.0 V
25. R_T = 4.00 KΩ
26. P_T = 576 mW


V
12 V
A
12 mA
E_{S1}
$E_T = E_{S1} + E_{S2}$
E_{S2}
R_1
R_2
R_3
R_1 = 500Ω
R_4 = 1.5 KΩ
V
36 V

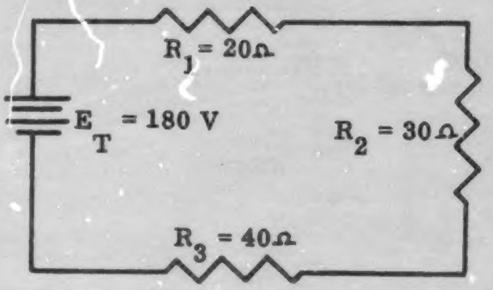
27. R_2 = 5.00Ω
28. R_T = 100 Ω
29. I_3 = 1.00 A
30. E_1 = 90.0 V

31. E_3 = 5.00 V
32. P_1 = 90.0 W
33. P_2 = 5.00 W
34. P_3 = 5.00 W


R_1 = 90Ω
E_T = 100 V
I_T = 1 A
E_2 = 5 V
R_3 = 5Ω

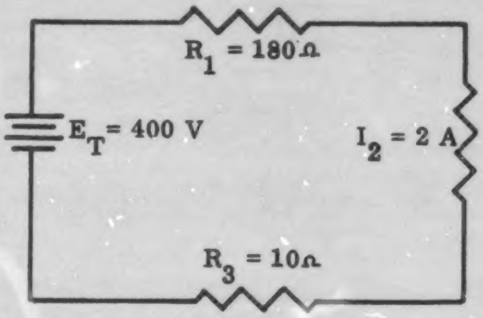
35. R_T = 90.0Ω
36. I_1 = 2.00 A
37. E_1 = 40.0 V

38. E_2 = 60.0 V
39. E_3 = 80.0 V
40. P_2 = 120 W


R_1 = 20Ω
E_T = 180 V
R_2 = 30Ω
R_3 = 40Ω

41. R_T = 200Ω
42. I_T = 2.00 A
43. P_T = 800 W
44. E_1 = 360 V
45. I_1 = 2.00 A

46. R_2 = 10.0Ω
47. E_2 = 20.0 V
48. P_2 = 40.0 W
49. E_3 = 20.0 V
50. P_3 = 40.0 W


R_1 = 180Ω
E_T = 400 V
I_2 = 2 A
R_3 = 10Ω

TEST **IV-A-1(T)**
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

D 1. Two resistors connected in series must have
A. the same resistance value.
B. the same voltage drop across them.
C. different resistance values.
D. the same current flowing through them.

B 2. With two equal resistances in series across a 90 Volt battery, each resistance will have a voltage of ____.
A. 30 V B. 45 V C. 90 V D. 180 V

C 3. In a series circuit, the current through R_1 is 1A. The current through R_2 must be ____.
A. 0.333 A B. 500 mA C. 1.00 A D. 2.00 A

C 4. If the filaments of several lamps are to be connected in series, they must have the same ____ rating.
A. resistance B. voltage C. current D. power

Directions: List the four characteristics for series circuit analysis.

$E_T = E_1 + E_2 + E_3 \ldots$ 5. Total Voltage

$I_T = I_1 = I_2 = I_3 \ldots$ 6. Total Current

$R_T = R_1 + R_2 + R_3 \ldots$ 7. Total Resistance

$P_T = P_1 + P_2 + P_3 \ldots$ 8. Total Power

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

Kirchhoff's 9. Ohm's Law and ____ Law can be very useful in solving series circuits.

Open 10. When a resistor in a series circuit becomes ____, the current is zero in all resistances.

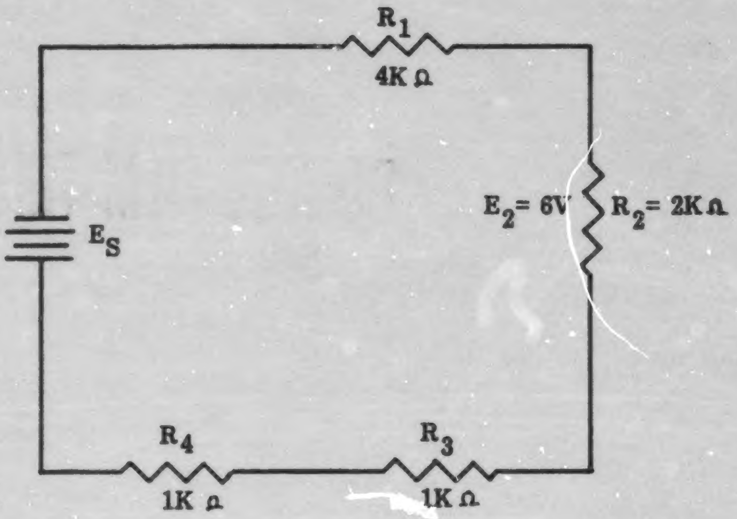
Larger 11. The total resistance in a series circuit will always be ____ than the largest resistance.

Increase 12. If a resistor in a series circuit becomes shortened, the total current will ____.

True 13. The sum of all the voltages around a series circuit will equal zero. (True or False)

Directions: Use the circuit below to solve for the indicated unknown values. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers.

14. I_T = 3.00 mA
15. E_S = 24.0 V
16. E_1 = 12.0 V
17. E_2 = 6.00 V
18. R_T = 8.00 K Ohms
19. P_4 = 9.00 mW
20. P_3 = 9.00 mW
21. P_2 = 18.0 mW
22. I_3 = 3.00 mA
23. P_1 = 36.0 mW
24. P_T = 72.0 mW
25. E_4 = 3.00 V



INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Parallel Resistive Circuits
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate an understanding of the relationship between voltage, current, resistance, and power in a parallel resistive circuit by constructing circuits, making circuit measurements, and making calculations for circuit values.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, figs. 59-64
MATERIALS:	Assignment Sheet - Parallel Resistive Circuits Experiment # 10 - Parallel Circuits - Resistance Experiment # 11 - Parallel Circuits - Kirchhoff's Law Test Sheet - Parallel Resistive Circuits
TOOLS AND EQUIPMENT:	Student lab station, component set
REFERENCES:	Fowler, Electricity - Principles and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

What is a parallel circuit? How does the voltage, current, resistance, and power in a parallel circuit compare with a series circuit? This lesson explains how to connect components in parallel across a voltage source. You will be studying voltage, branch currents, resistance, and power as they apply to parallel circuits. You will continue to use Ohm's Law and the power formulas for parallel circuits. Your application of the Ohm's Law formula during series circuits will help you during this lesson and in the next lesson on combination resistive circuits.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Circuit Characteristics	1. Parallel resistive circuits a. Multiload circuit with more than one path for current b. Components connected side by side
Show Transparency fig. 59	2. Current a. Can be several paths for current

	b. Total circuit current is equal to the sum of the branch currents
	c. $I_T = I_1 + I_2 + I_3 \ldots$
Show Transparency fig. 60	3. Resistance
	a. The reciprocal of the total resistance of a parallel circuit is equal to the sum of the reciprocals of the individual resistances
Show Transparency fig. 61	b. Parallel resistors could be replaced by one equivalent resistance
	c. $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots$ or $R_T = 1/(1/R_1 + 1/R_2 + 1/R_3 \ldots)$
	d. $R_T = (R_1 \times R_2) / (R_1 + R_2)$ -- special formula for only 2 values
	e. R_T = Value/# of resistors -- special formula for several resistors of the same value
Show Transparency fig. 62	4. Voltage
	a. Source voltage is across each of the load resistors
	b. Polarity of voltage across resistors is the same as the source
	c. $E_T = E_1 = E_2 = E_3 \ldots$
	5. Power
	a. Total power is equal to the sum of the individual power values
	b. Power is dissipated by each resistor
	c. $P_T = P_1 + P_2 + P_3 \ldots$
B. Kirchhoff's Current Law	1. Used for parallel circuit analysis
Show Transparency fig. 63	2. The sum of the current entering a junction must equal the current leaving that junction
	3. Can be used to help solve parallel circuits
C. Circuit Analysis	1. Using circuit characteristics
Show Transparency fig. 64	a. $I_T = I_1 + I_2 + I_3 \ldots$
	b. $E_T = E_1 = E_2 = E_3 \ldots$
	c. $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots$
	d. $P_T = P_1 + P_2 + P_3 \ldots$
	2. Kirchhoff's current law
	a. Use to find current flow through circuit branch
	b. Use to find total current

II. PRESENTATION (CONT'.)

3. Ohm's Law
    a. Ohm's Law applies as long as all values are associated with one resistance
    b. Example: $R_2 = E_2 / I_2$
4. Solve circuit problems using all of the above

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Parallel Resistive Circuits
2. Experiment # 10 - Parallel Circuits - Resistive
3. Experiment # 11 - Parallel Circuits - Kirchhoff's Law
4. Check each student's work for completeness and accuracy
5. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

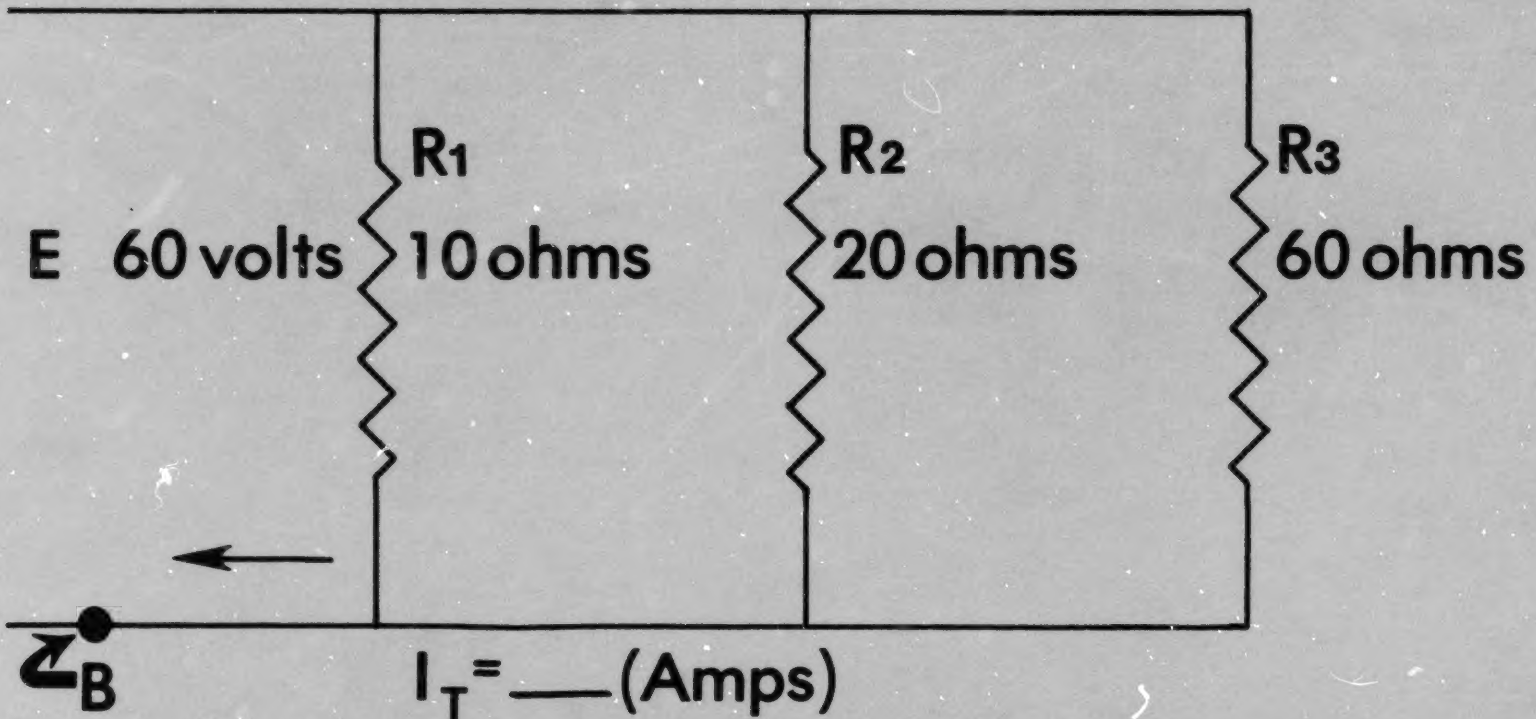
1. Ask oral questions
2. Test Sheet - Parallel Resistive Circuits
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Combination Resistive Circuits

Current in a Parallel Circuit


R1
10 ohms
R2
20 ohms
R3
60 ohms
E 60 volts
B

I_T = ___ (Amps)

What is the total current passing through point 'B' in the circuit?

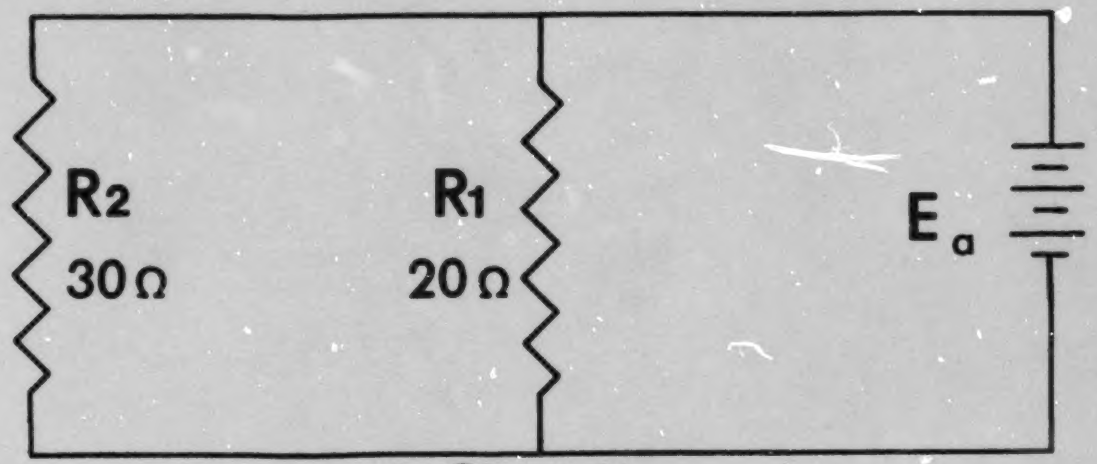
Fig. 59

Resistance in Parallel Circuits

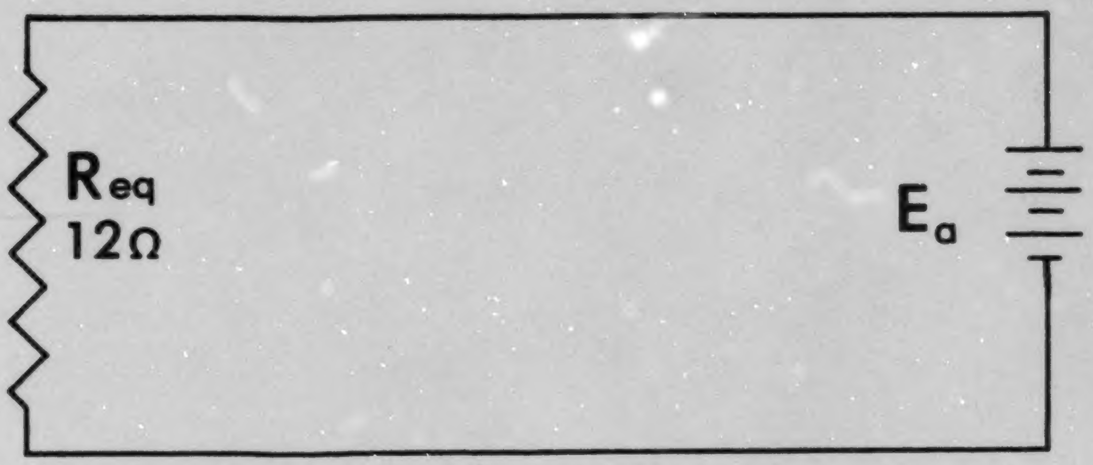
The total resistance of a parallel circuit is equal to the sum of the individual resistances.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \cdots \frac{1}{R_N}$$

Parallel and Equivalent Circuits

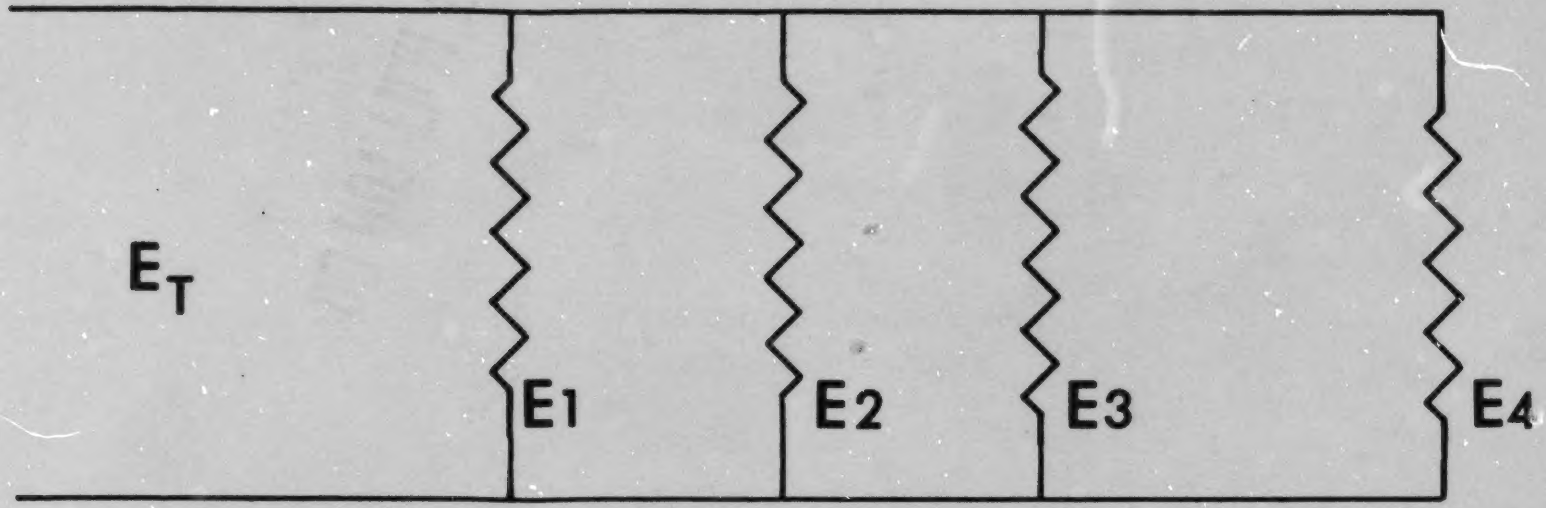

R_2
30 Ω
R_1
20 Ω
E_a

Circuit



Equivalent Circuit

Parallel Circuit Voltage



In a parallel circuit the voltage across each branch is the same. or

$$E_T = E_1 = E_2 = E_3 \ldots E_N$$

Kirchhoff's Current Law

☆

The current leaving a junction always equals the current entering that junction.

☆

PARALLEL CIRCUIT CHARACTERISTICS

$$E_T = E_1 = E_2 = E_3 \ldots$$

$$I_T = I_1 + I_2 + I_3 \ldots$$

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots}$$

$$P_T = P_1 + P_2 + P_3 \ldots$$

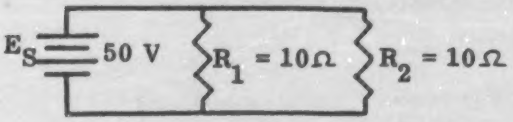
PARALLEL RESISTIVE CIRCUITS

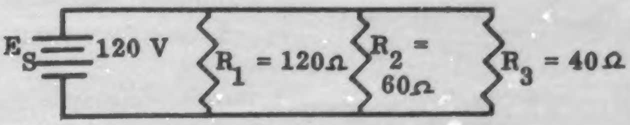
IV-B-1(AS)
Key

Name ______________________________ Date ____________________

Directions: Each student will complete this assignment on an individual basis. Answer questions in the spaces provided. Problem answers should be rounded off to three significant figures and written using the proper metric prefix. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

Find the indicated values for the following circuits.





1. E_1 = 50.0 V
2. I_1 = 5.00 A
3. E_2 = 50.0 V
4. I_2 = 5.00 A
5. E_1 = 120 V
6. E_2 = 120 V
7. E_3 = 120 V
8. I_1 = 1.00 A
9. I_2 = 2.00 A
10. I_3 = 3.00 A

Voltage 11. With two resistances connected in parallel, the ____ across each resistor must be the same.

2.00 A 12. With 100 V applied across ten 50 Ohm resistances in parallel, the current through each resistance equals ____.

Voltage 13. In a parallel circuit, the ____ appears across each branch.

$E_T = E_1 = E_2 \ldots$ 14. In a parallel circuit, E_T = ____.

Directions: Find the total resistance for parallel circuits containing the following resistor values.

20.0Ω 15. 80Ω , 80Ω and 40Ω

2.50Ω 16. 20Ω , 5Ω , 10Ω , and 20Ω

4.00Ω 17. 20Ω , 10Ω and 10Ω

3.33Ω 18. 10Ω , 20Ω , 20Ω and 10Ω

1.88 KΩ 19. 3 KΩ and 5 KΩ

1.66Ω 20. 3Ω , 5Ω , 20Ω and 50Ω

9.09Ω 21. 2 KΩ 4 KΩ , 20 KΩ , 5 KΩ and 10 KΩ

4.00 MΩ 22. 5 MΩ and 20 MΩ

1.87Ω 23. 3Ω , 5Ω and 15 KΩ

30.0Ω 24. Five 150Ω

21.4Ω 25. Seven 150Ω

1.00 KΩ 26. 2 KΩ and 2 KΩ

25.0Ω 27. 50Ω and 50Ω

5.45Ω 28. 10Ω , 20Ω and 30Ω

Added — 29. In a parallel circuit, the current in each branch is ____ together to determine the total current.

$R_T = \frac{1}{1/R_1 + 1/R_2}$. — 30. In a parallel circuit, R_T = ____.

$I_T = I_1 + I_2 \ldots$ — 31. In a parallel circuit, I_T = ____.

Voltage — 32. The ___ is the same across all parts of a parallel circuit.

Less — 33. The total resistance in a parallel circuit is always ____ than the smallest branch resistance.

20.0Ω — 34. What resistance must be placed in parallel with 30 ohms to provide a total resistance of 12 ohms?

Half — 35. Two equal resistors in parallel produce an equivalent resistance that is ____ the value of one of the resistors.

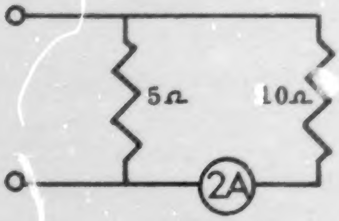
Increase — 36. Adding resistors will ____ the total current in a parallel circuit.

Current — 37. In a parallel circuit, the ____ divides among branches inversely proportional to the branch resistance.

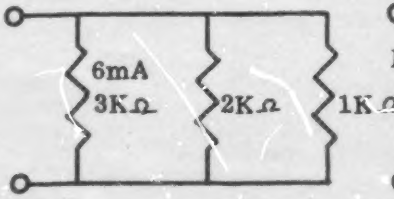
Open — 38. If the total circuit current decreases in a parallel circuit, a/an ____ circuit failure should be suspected.

$P_T = P_1 + P_2 \ldots$ — 39. In a parallel circuit, P_T = ____.

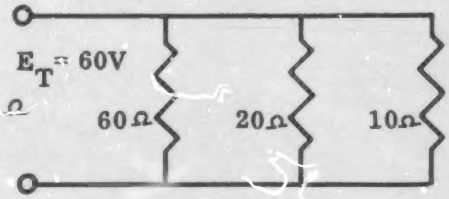
Directions: Solve the following circuits for the indicated unknown values.



40. E_T = 20.0 V
41. I_T = 6.00 A
42. R_T = 3.33Ω



43. R_T = 545Ω
44. I_T = 33.0 mA
45. P_T = 594 mW

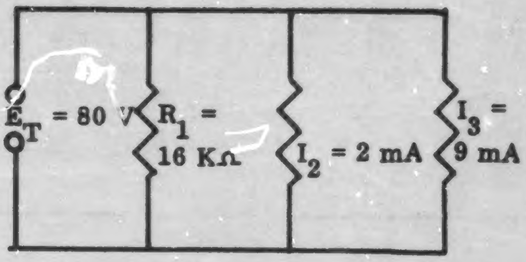


46. I_T = 10.0 A
47. R_T = 6.00Ω
48. P_T = 600 W

IV-B-1(AS)
Key

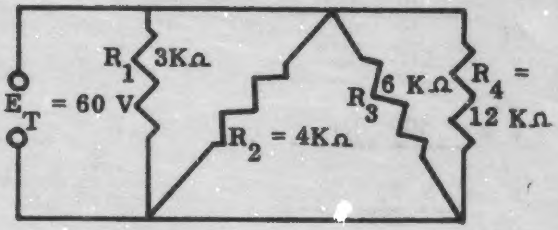
49. R_T = 5.00 KΩ
50. I_T = 16.0 mA
51. P_T = 1.28 W
52. I_1 = 5.00 mA
53. R_2 = 40.0 KΩ

54. R_3 = 8.89 KΩ
55. P_1 = 400 mW
56. P_2 = 160 mW
57. P_3 = 720 mW


E_T = 80 V
R_1 =
16 KΩ
I_2 = 2 mA
I_3 =
9 mA

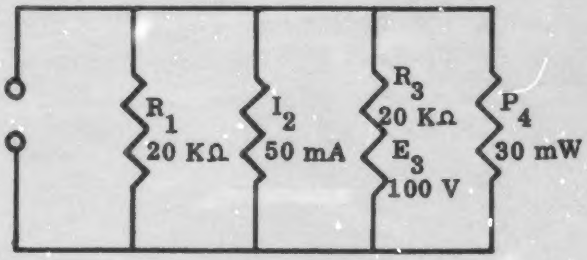
58. R_T = 1.20 KΩ
59. I_T = 50.0 mA
60. I_1 = 20.0 mA
61. I_2 = 15.0 mA
62. I_3 = 10.0 mA

63. I_4 = 5.00 mA
64. P_T = 3.00 W
65. P_1 = 1.20 W
66. P_4 = 300 mW


R_1
3KΩ
E_T = 60 V
R_2 = 4KΩ
R_3
6 KΩ
R_4 =
12 KΩ

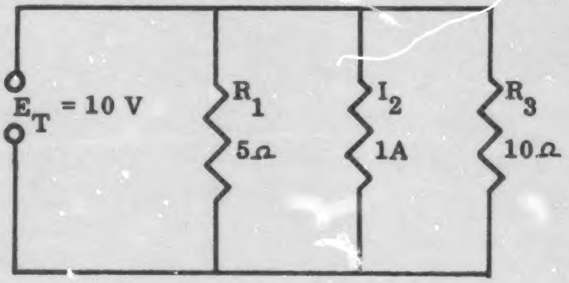
67. I_T = 60.3 mA
68. R_T = 1.66 KΩ
69. I_1 = 5.00 mA
70. P_T = 6.03 W
71. I_3 = 5.00 mA
72. I_4 = 300 µA

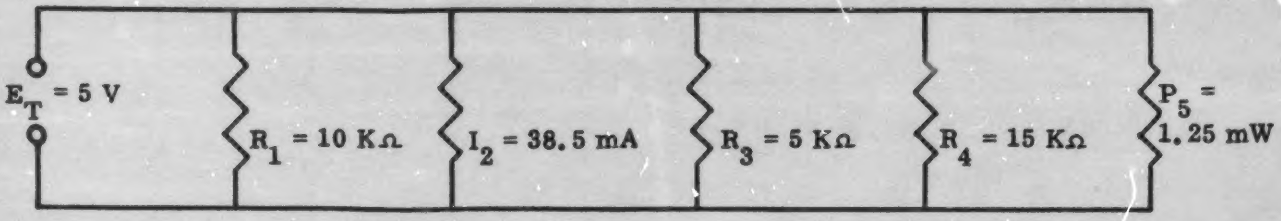
73. R_2 = 2.00 KΩ
74. R_4 = 333 KΩ
75. P_1 = 500 mW
76. P_2 = 5.00 W
77. P_3 = 500 mW


R_1
20 KΩ
I_2
50 mA
R_3
20 KΩ
E_3
100 V
P_4
30 mW

78. R_T = 2.50 Ω
79. P_T = 40.0 W
80. I_T = 4.00 A
81. R_2 = 10.0 Ω
82. I_1 = 2.00 A

83. I_3 = 1.00 A
84. P_1 = 20.0 W
85. P_2 = 10.0 W
86. P_3 = 10.0 W


E_T = 10 V
R_1
5Ω
I_2
1A
R_3
10Ω


$E_T = 5$ V
$R_1 = 10$ KΩ
$I_2 = 38.5$ mA
$R_3 = 5$ KΩ
$R_4 = 15$ KΩ
$P_5 =$ 1.25 mW

87. R_T = 123Ω
88. I_T = 40.6 mA
89. P_T = 203 mW
90. I_1 = 500 μA
91. P_1 = 2.50 mW
92. R_2 = 130Ω
93. P_2 = 132 mW
94. I_3 = 1.00 mA
95. P_3 = 5.00 mW
96. I_4 = 333 μA
97. P_4 = 1.67 mW
98. I_5 = 250 μA
99. R_5 = 20.0 KΩ
100. E_5 = 5.00 V

TEST IV-B-1(T)
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

B 1. Two resistors connected in parallel must have
A. the same resistance value.
B. the same voltage drop across them.
C. different resistance values.
D. the same current flowing through them.

A 2. If 100 V is across ten 50 Ohm resistances connected in parallel, the current through each resistance is ____.
A. 2.00 A B. 10.0 A C. 20.0 A D. 100 A

C 3. When two parallel resistances are dissipating 10 Watts each, the total power from the source is ____.
A. 5 Watts B. 10 Watts C. 20 Watts D. 100 Watts

D 4. If a parallel circuit containing resistances of 12, 15 and 20 Ohm is connected across as 120 V source, the total current is ___.
A. 240 mA B. 2.40 mA C. 0.240 A D. 2.40 A

Directions: List the four characteristics for parallel circuit analysis.

$E_T = E_1 = E_2 = E_3 \ldots$ 5. Total Voltage

$I_T = I_1 + I_2 + I_3 \ldots$ 6. Total Current

$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots$ 7. Total Resistance

$P_T = P_1 + P_2 + P_3 \ldots$ 8. Total Power

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

Kirchhoff's 9. Ohm's Law and ___ Current Law can be very useful in solving parallel circuit.

True 10. When a parallel circuit branch opens, the current will be normal in the other branches. (True or False)

12.0 V

11. If a 10 Ohm and a 15 Ohm resistor are connected in a parallel circuit having a total current of 2.00 A, the applied voltage is ____.

Voltage

12. The ____ is the same across each branch of a parallel circuit.

False

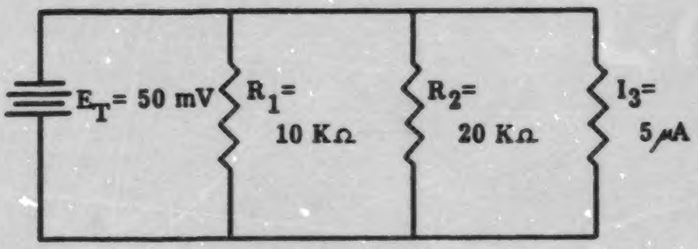
13. In a parallel circuit, the current is the same in all branches. (True or False)

False

14. If a branch of a parallel circuit becomes shorted, the rest of the circuit will continue to function normally. (True or False)

Directions: Use the circuit below to solve for the indicated unknown values. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers.

15. I_T = 12.5 μA
16. R_T = 4.00 K Ohms
17. P_T = 625 nW
18. E_1 = 50.0 mV
19. E_3 = 50.0 mV
20. I_1 = 5.00 μA
21. I_2 = 2.50 μA
22. R_3 = 10.0 K Ohm
23. P_1 = 250 n W
24. P_2 = 125 n W
25. P_3 = 250 n W



INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Complex Resistive Circuits
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate an understanding of series-parallel circuits, Thevenin's and Norton's Theorems, Delta-Wye circuits, and voltage divider circuits by answering questions, constructing circuits, and making circuit calculations.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, figs. 65-69
MATERIALS:	Assignment Sheet - Complex Resistive Circuits Experiment # 12 - Series Parallel Circuits Experiment # 13 - Thevenin's and Norton's Theorems Experiment # 14 - Reostats and Potentiometers Experiment # 15 - The Voltage Divider Test Sheet - Complex Resistive Circuits
TOOLS AND EQUIPMENT:	Student lab station, component set
REFERENCES:	Fowler, Electricity - Principles and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

During this lesson you will study the construction and analysis of series-parallel circuits. You will use diagrams and mathematics to solve problems of resistance, current, voltage, and power. You will also solve delta-wye circuits. Delta-wye circuit conversions often are helpful in solving complex resistive circuits. Voltage divider circuits are simply series-parallel circuits used to reduce the size of a fixed voltage. You will see these complex resistive circuits in all types of electronics equipment. If you learn to analyze them correctly, it will be a great help to you in repairing equipment.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Series-Parallel Circuits Show Transparency fig. 65	1. Contains some feature of both series and parallel circuits 2. Can be reduced by using characteristics of series and parallel circuits

3. Ohm's law and Kirchhoff's laws can be used to find circuit relationships

B. Circuit Theorems

Show Transparency fig. 66

1. Thevenin's Theorem
    - a. Used to simplify voltages in a network
    - b. An entire network between two terminals can be replaced by a voltage connected in series with a resistance across two two terminals
2. Norton's Theorem
    - a. Used to analyze circuit on current
    - b. An entire network between two terminals can be replaced with a current source and a parallel resistance connected between the two terminals

C. Delta-Wye Circuits

Show Transparency fig. 67

1. Delta circuits shaped like Greek letter delta
2. Wye circuit shaped like letter Y
3. Conversions
    - a. Delta to Wye formulas:
        - 1.) $R_1 = (R_A \times R_C) / (R_A + R_B + R_C)$
        - 2.) $R_2 = (R_B \times R_C) / (R_A + R_B + R_C)$
        - 3.) $R_3 = (R_A \times R_B) / (R_A + R_B + R_C)$
    - b. Wye to Delta formulas
        - 1.) $R_A = (R_1R_2 + R_1R_3 + R_2R_3) / R_2$
        - 2.) $R_B = (R_1R_2 + R_1R_3 + R_2R_3) / R_1$
        - 3.) $R_C = (R_1R_2 + R_1R_3 + R_2R_3) / R_3$

D. Voltage Dividers

Show Transparency fig. 68

1. Unloaded
    - a. Series circuit
    - b. Voltage values change as current flow changes

Show Transparency fig. 69

2. Loaded
    - a. Series parallel circuit
    - b. Load must not change
    - c. Select resistors for value and power rating

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Complex Resistive Circuits
2. Experiment # 12 - Series Parallel Circuits
3. Experiment # 13 - Thevenin's and Norton's Theorems
4. Experiment # 14 - Rheostats and Potentiometers
5. Experiment # 15 - The Voltage Divider
6. Check each student's work for completeness and accuracy
7. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - Complex Resistive Circuits
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Meter Circuits

COMBINATION CIRCUIT

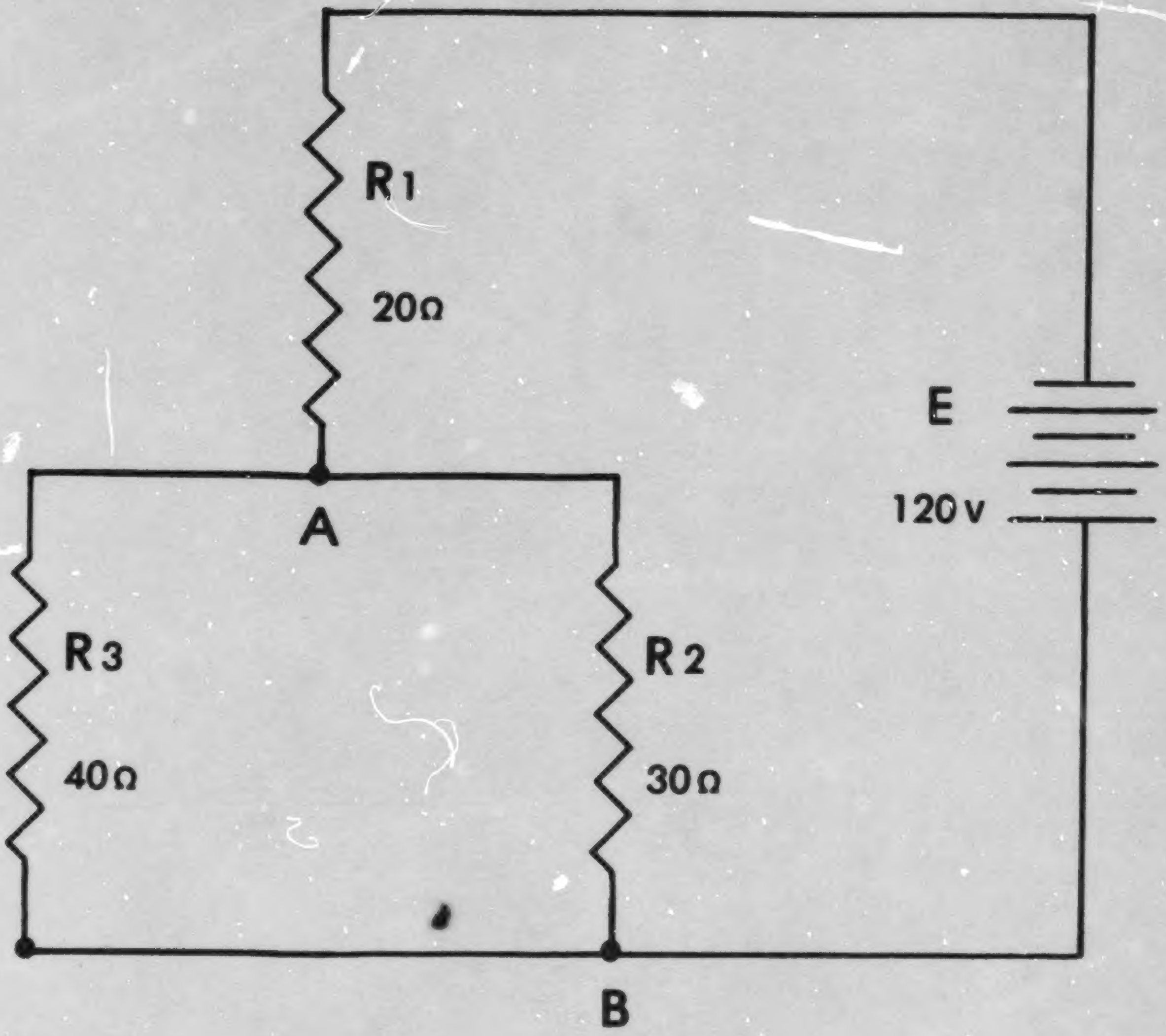

R1
20Ω
A
R3
40Ω
R2
30Ω
B
E
120 v

Fig. 65

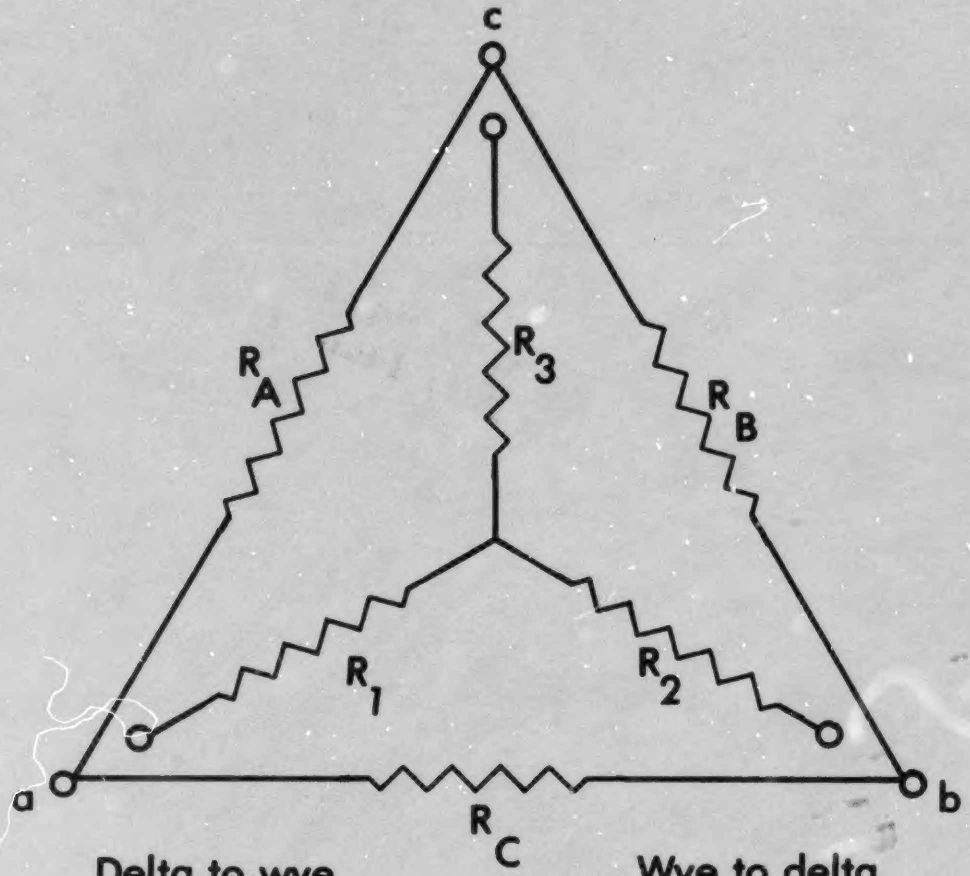
THEVENIN'S THEOREM

An entire network between two terminals can be replaced by a voltage connected in series with a resistance across the two terminals.

NORTON'S THEOREM

An entire network between two terminals can be replaced with a current source and a parallel resistance connected between the two terminals.

DELTA-WYE CIRCUIT CONVERSION



Delta to wye

$$R_1 = \frac{R_A \times R_C}{R_A + R_B + R_C}$$

$$R_2 = \frac{R_B \times R_C}{R_A + R_B + R_C}$$

$$R_3 = \frac{R_B \times R_A}{R_A + R_B + R_C}$$

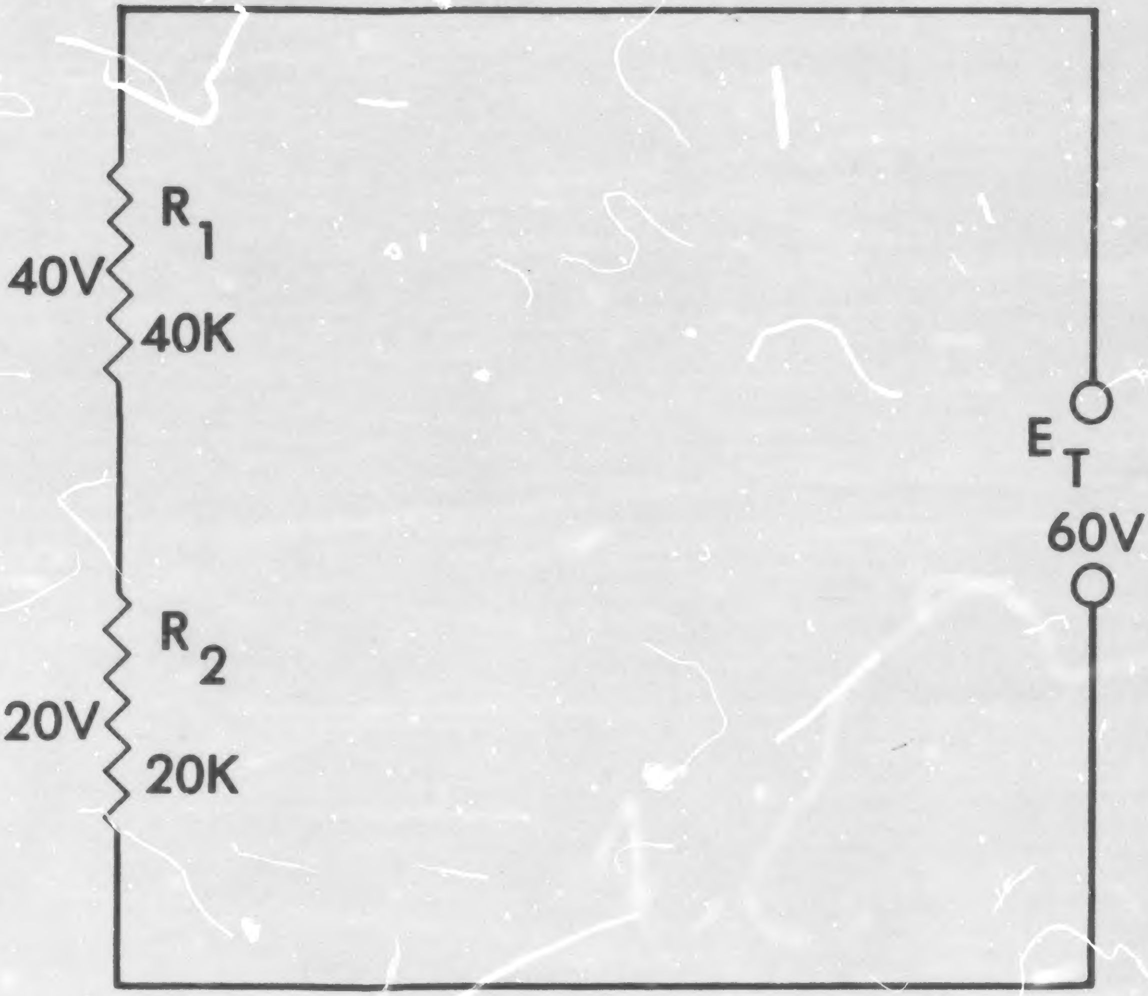
Wye to delta

$$R_A = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_2}$$

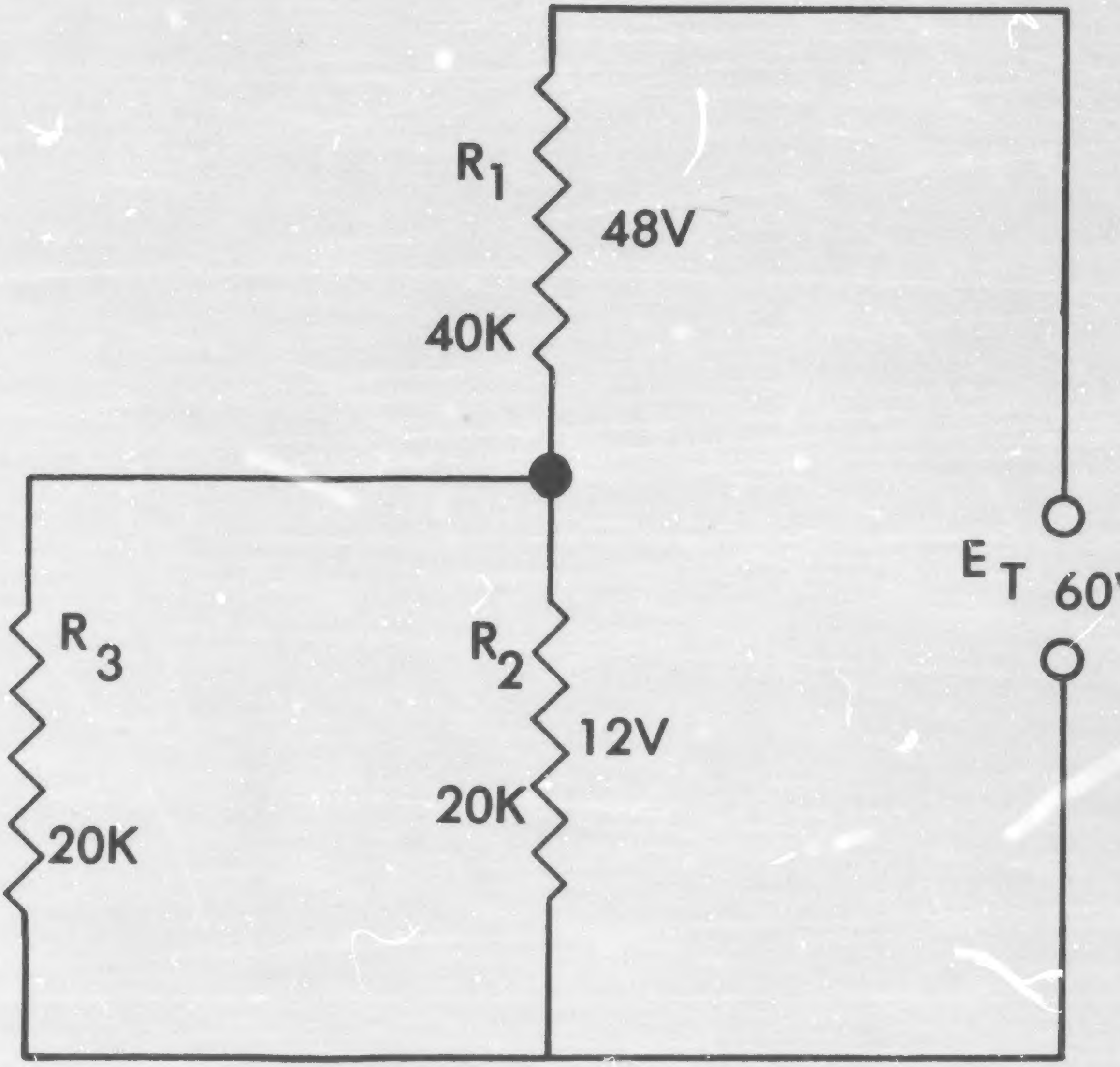
$$R_B = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_1}$$

$$R_C = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_3}$$

VOLTAGE DIVIDER UNLOADED


R1
40V
40K
R2
20V
20K
ET
60V

VOLTAGE DIVIDER LOADED

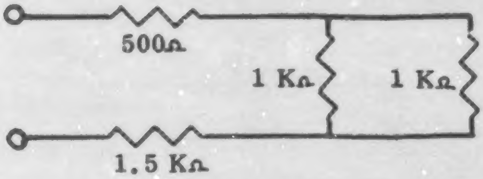

R1
48V
40K
R3
20K
R2
12V
20K
ET 60V

COMPLEX RESISTIVE CIRCUITS

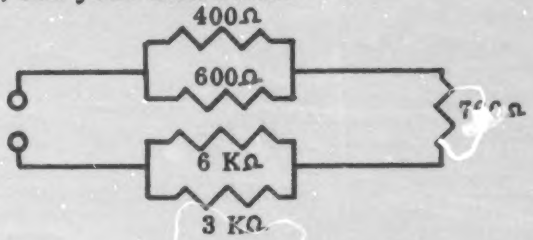
IV-C-1(AS)
Key

Name ______________________________ Date ___________________________

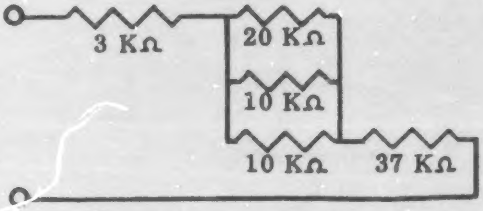
Directions: Each student will complete this assignment sheet on an individual basis. Solve the following circuits for the indicated unknown values. Answer questions in the spaces provided. Problem answers should be rounded off to three significant figures and written in the space provided using the proper metric prefix. Use your class notes and textbook as reference. If you have any questions, ask your instructor.


500Ω
1 KΩ
1 KΩ
1.5 KΩ

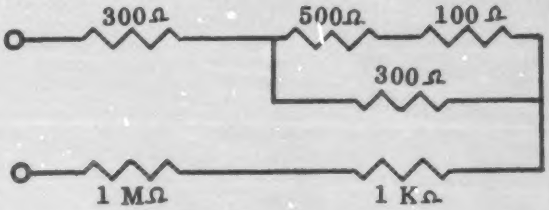
1. R_T = 2.5 KΩ


400Ω
600Ω
760Ω
6 KΩ
3 KΩ

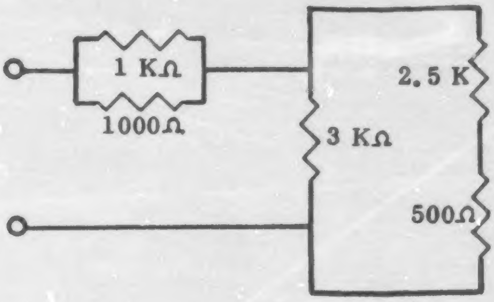
2. R_T = 3 KΩ


3 KΩ
20 KΩ
10 KΩ
10 KΩ
37 KΩ

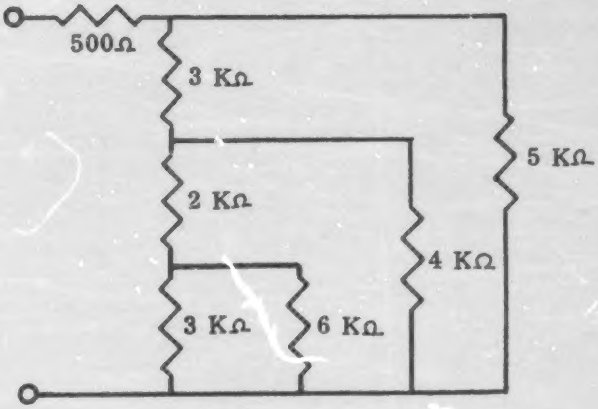
3. R_T = 44 KΩ


300Ω
500Ω
100Ω
300Ω
1 MΩ
1 KΩ

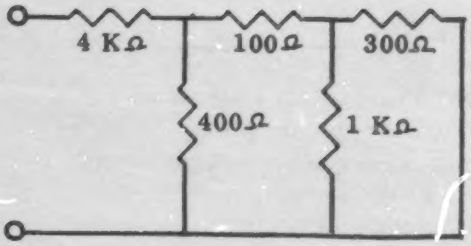
4. R_T = 1 MΩ


1 KΩ
1000Ω
2.5 K
3 KΩ
500Ω

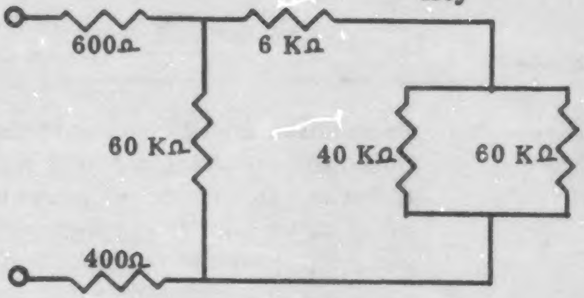
5. R_T = 2KΩ


500Ω
3 KΩ
5 KΩ
2 KΩ
4 KΩ
3 KΩ
6 KΩ

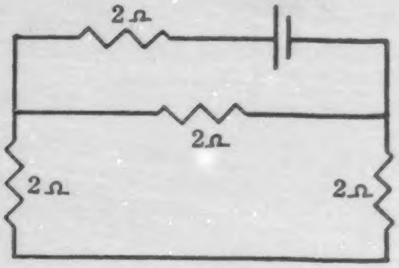
6. R_T = 3 KΩ


4 KΩ
100Ω
300Ω
400Ω
1 KΩ

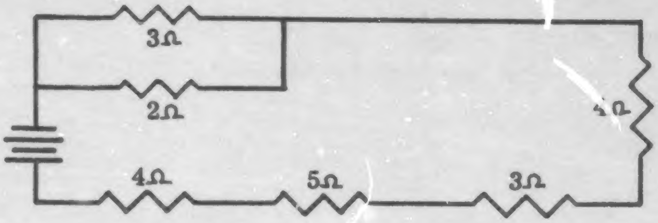
7. R_T = 4.18 KΩ


600Ω
6 KΩ
60 KΩ
40 KΩ
60 KΩ
400Ω

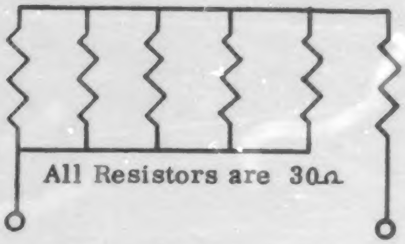
8. R_T = 21.0 KΩ



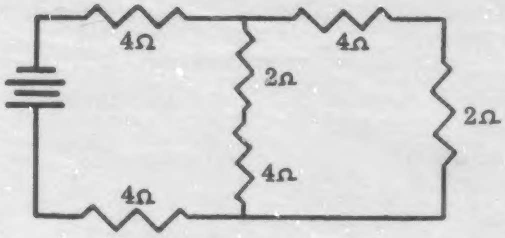
9. R_T = 3.33Ω


3Ω
2Ω
4Ω
4Ω
5Ω
3Ω

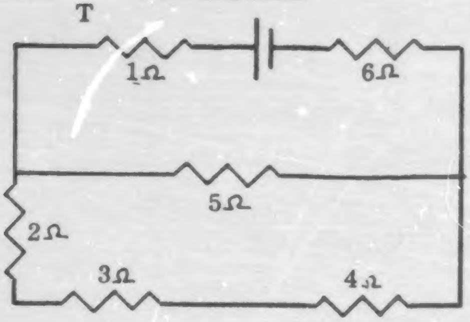
10. R_T = 17.2 Ω


All Resistors are 30Ω

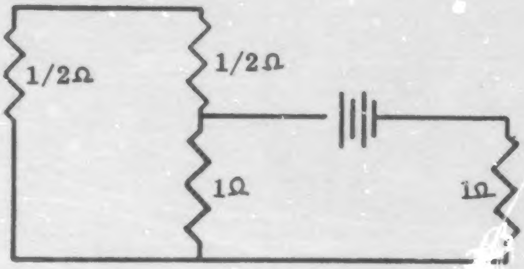
11. R_T = 36.0Ω


4Ω
4Ω
2Ω
2Ω
4Ω
4Ω

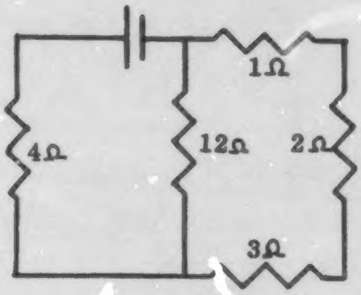
12. R_T = 11.0Ω


1Ω
6Ω
5Ω
2Ω
3Ω
4Ω

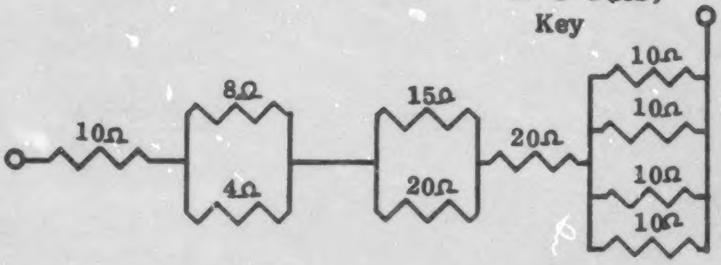
13. R_T = 10.2Ω


1/2Ω
1/2Ω
1Ω
1Ω

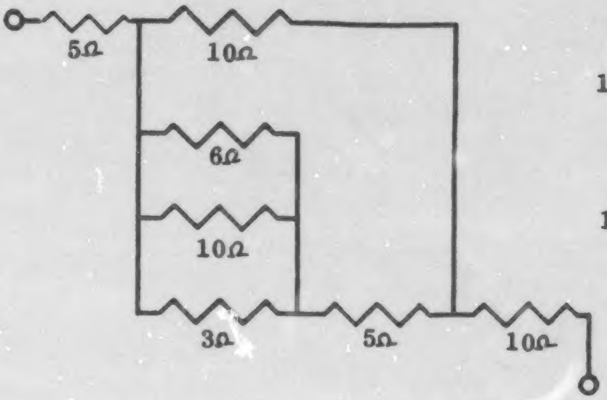
14. R_T = 1.50Ω

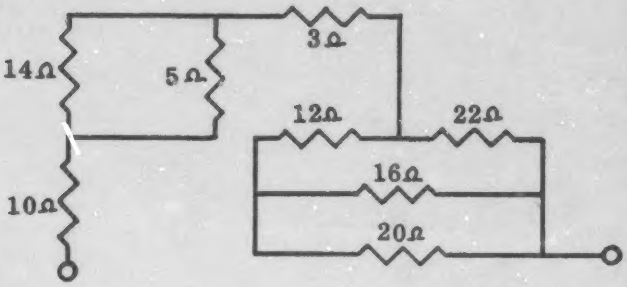

1Ω
4Ω
12Ω
2Ω
3Ω

15. R_T = 8.00Ω


10Ω
8Ω
4Ω
15Ω
20Ω
20Ω
10Ω
10Ω
10Ω
10Ω

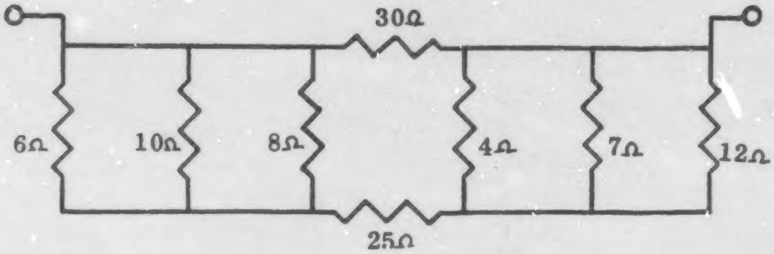
16. R_T = 43.7Ω

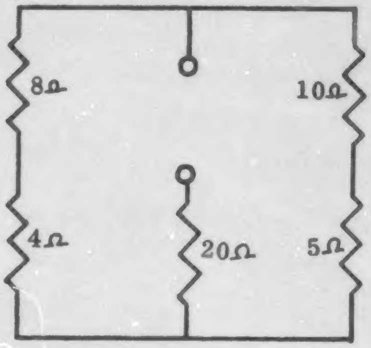

5Ω
10Ω
6Ω
10Ω
3Ω
5Ω
10Ω


14Ω
5Ω
3Ω
12Ω
22Ω
16Ω
10Ω
20Ω

17. R_T = 19.0Ω

18. R_T = 27.4Ω


30Ω
6Ω
10Ω
8Ω
4Ω
7Ω
12Ω
25Ω

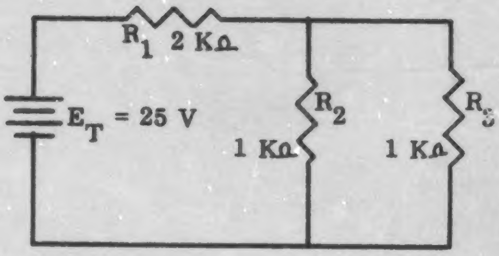

8Ω
10Ω
4Ω
20Ω
5Ω

19. R_T = 14.9Ω

20. R_T = 26.7Ω

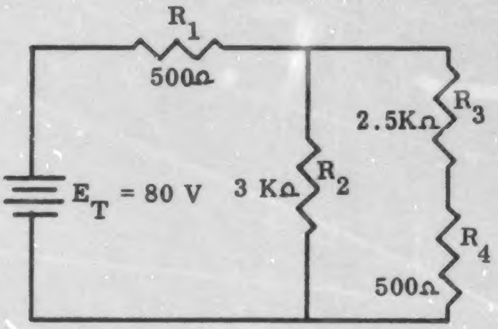
21. R_T = 2.50 KΩ
22. I_T = 10.0 mA
23. I_1 = 10.0 mA
24. I_2 = 5.00 mA

25. I_3 = 5.00 mA
26. E_1 = 20.0 V
27. E_2 = 5.00 V
28. E_3 = 5.00 V


R_1 2 KΩ
E_T = 25 V
R_2
1 KΩ
R_3
1 KΩ

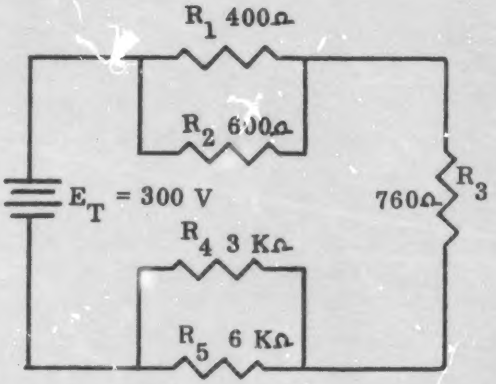
29. R_T = 2.00 KΩ
30. I_T = 40.0 mA
31. E_1 = 20.0 V
32. E_2 = 60.0 V
33. E_3 = 50.0 V

34. E_4 = 10.0 V
35. I_1 = 40.0 mA
36. I_2 = 20.0 mA
37. I_3 = 20.0 mA
38. I_4 = 20.0 mA

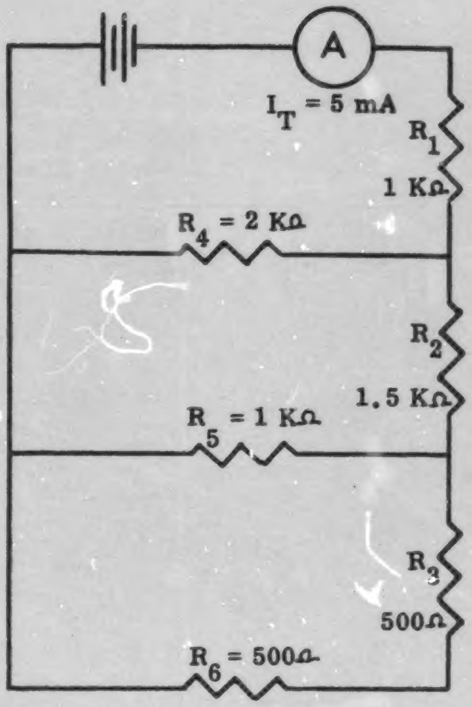

R_1
500Ω
2.5KΩ
R_3
E_T = 80 V
3 KΩ
R_2
R_4
500Ω

39. R_T = 3.00 KΩ
40. I_T = 100 mA
41. E_1 = 24.0 V
42. E_2 = 24.0 V

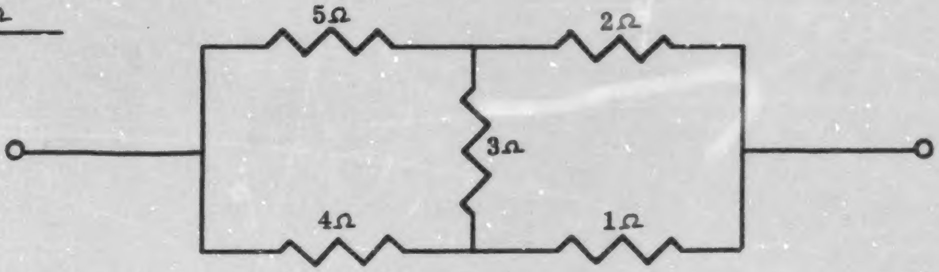
43. E_3 = 76.0 V
44. E_4 = 200 V
45. E_5 = 200 V


R_1 400Ω
R_2 600Ω
E_T = 300 V
760Ω
R_3
R_4 3 KΩ
R_5 6 KΩ

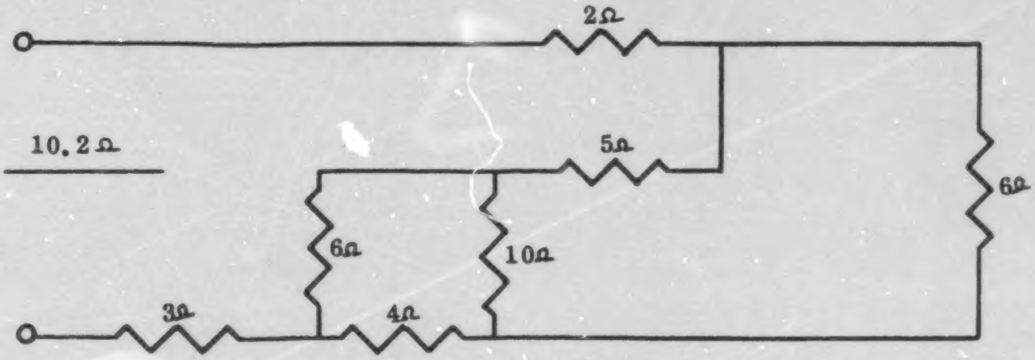
46. R_T = 2.00 K
47. E_T = 10.0 V
48. I_1 = 5.00 mA
49. I_2 = 2.50 mA
50. I_3 = 1.25 mA
51. I_4 = 2.50 mA
52. I_5 = 1.25 mA
53. I_6 = 1.25 mA
54. E_1 = 5.00 V
55. E_2 = 3.75 V
56. E_3 = 625 mV
57. E_4 = 5.00 V
58. E_5 = 1.25 V
59. E_6 = 625 mV
60. P_T = 50.0 mW
61. P_1 = 25.0 mW
62. P_2 = 9.38 mW
63. P_3 = 781 μW
64. P_4 = 12.5 mW
65. P_5 = 1.56 mW
66. P_6 = 781 μW


A
I_T = 5 mA
R_1
1 KΩ
R_4 = 2 KΩ
R_2
1.5 KΩ
R_5 = 1 KΩ
R_3
500Ω
R_6 = 500Ω

67. R_T = 2.91Ω


5Ω
2Ω
3Ω
4Ω
1Ω

68. R_T = 10.2Ω


2Ω
5Ω
6Ω
6Ω
10Ω
3Ω
4Ω

TEST

IV-C-1(T)
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

C 1. The total resistance of the circuit in figure 1 is ____.
A. 3.00 K Ohms C. 5.00 K Ohms
B. 4.00 K Ohms D. 6.00 K Ohms

B 2. The total current in the circuit in figure 1 is ____.
A. 0.100 A C. 1.00 mA
B. 0.0100 A D. 0.100 mA

C 3. The voltage drop across R_1 in figure 1 is ____.
A. 10.0 V C. 30.0 V
B. 20.0 V D. 40.0 V

A 4. The current through R_3 in figure 1 is ____.
A. 0.00667 A C. 6.67 A
B. 66.7 mA D. 10.0 mA

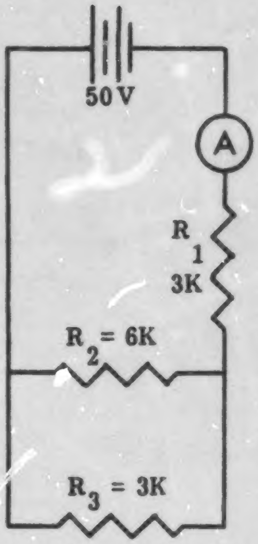


figure 1

B 5. The total power dissipated by the circuit in figure 1 is ____.
A. 5.00 W C. 50.0 mW
B. 0.500 W D. 5.00 mW

A 6. The total resistance of the circuit in figure 2 is ____.
A. 1.00 M Ohms C. 600 Ohms
B. 900 K Ohms D. 500 Ohms

B 7. The total current in the circuit in figure 2 is ____.
A. 0.010 mA C. 1.00 A
B. 0.100 mA D. 10.0 A

B 8. The voltage across R_3 in the circuit in figure 2 is ____.
A. 30.0 V C. 60.0 V
B. 50.0 V D. 75.0 V

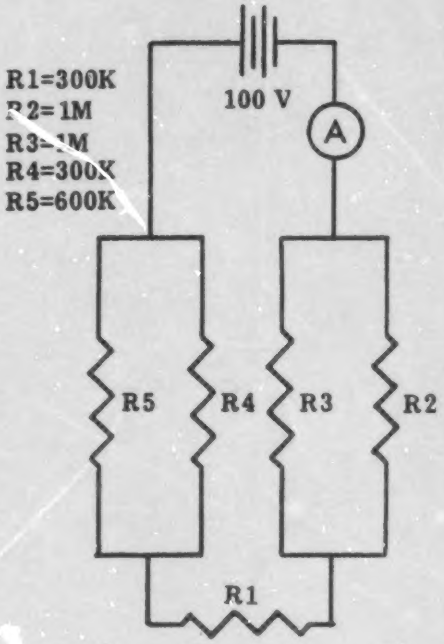


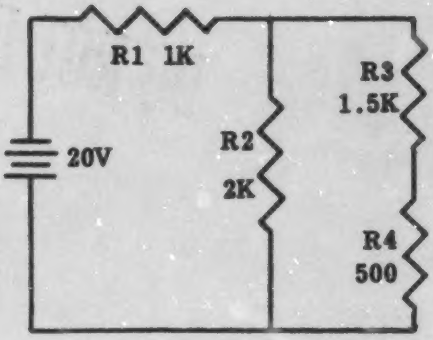
figure 2

A 9. The voltage drop across R_5 in the circuit in figure 2 is ____.
A. 20.0 V B. 30.0 V C. 50.0 V D. 60.0 V

D 10. The power dissipated by R_1 in the circuit in figure 2 is ____.
A. 3.00 W B. 300 mW C. 30.0 mW D. 3.00 mW

B 11. The total current in the circuit in figure 3 is ____.
A. 1.00 mA C. 1.00 A
B. 10.0 mA D. 10.0 A

figure 3



D 12. The total resistance in the circuit in figure 3 is ____.
A. 5.00 K Ohms C. 3.00 K Ohms
B. 4.00 K Ohms D. 2.00 K Ohms

B 13. The voltage drop across R_2 in the circuit in figure 3 is ____.
A. 5.00 V C. 15.0 V
B. 10.0 V D. 20.0 V

B 14. The voltage drop across R_1 in the circuit in figure 3 is ____.
A. 5.00 V B. 10.0 V C. 15.0 V D. 20.0 V

B 15. The total power dissipated by the circuit in figure 3 is ____.
A. 2.00 W B. 0.200 W C. 20.0 mW D. 20.0 V

Directions: Design a voltage divided circuit to provide 9 Volts at 50 mA from a 12 Volt power supply. Write the values indicated in the spaces provided. Be sure to check your answers.

55.0 MA 16. Total supply current.

5.00 mA 17. Bleeder current.

1.80 K Ohms 18. Bleeder resistor valve.

54.5 Ohms 19. Dropping resistor valve.

660 mW 20. Total circuit power with load.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

IV-D-1(I)

SUBJECT:	D.C. Meter Circuits
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate an understanding of D.C. meter circuits by answering questions, making circuit calculations, and constructing voltmeter, ammeter, ohmmeter, and bridge circuits.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500 figs. 70-74
MATERIALS:	Assignment Sheet - D.C. Meter Circuits Experiment # 16 - D.C. Voltmeter Multipliers Experiment # 17 - D.C. Ammeter Shunts Experiment # 18 - The Series Ohmmeter Experiment # 19 - The Wheatstone Bridge Test Sheet - D.C. Meter Circuits
TOOLS AND EQUIPMENT:	Student lab station, component set
REFERENCES:	Fowler, Electricity - Principles and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Do you know how a voltmeter measures the voltage in a circuit? How is a meter movement calibrated to measure different values of voltage? Meter movements can be used to measure voltage, current, and resistance by placing them in the proper circuit. In this lesson we will learn to extend the range of a meter to measure different values of voltage and current. We will also learn how to measure resistance using a meter and by the bridge circuit method. This knowledge will benefit you in many ways. You will use your knowledge of circuits to understand the operation of meter circuits.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TODO OR SAY
A. Meter Movements Show Transparency fig. 70	1. Parts of d'Arsonval movement a. Permanent magnet b. Coil c. Coil shaft with bearings d. Pointer e. Return springs

2. Sensitivity
   a. Built in and cannot be changed
   b. Current required for full scale deflection (Ex 25 μA)
   c. Voltage required for the amount of current for full scale deflection (Ex 50 mV - 1 mA)
   d. Current for full scale deflection and movement resistance (Ex 1 mA - 50 Ohms)
3. Operation
   a. Works on the principle of like magnetic poles repel
   b. Magnetic field (permanent)
   c. Current through coil produces field
   d. Current through coil produces needle deflection proportional to the current value
4. Taut-Band Construction
   a. Wire replaces needle bearings and shaft
   b. More rugged construction

B. Ammeters

Show Transparency fig. 71

1. Meter shunts - a resistance placed in parallel with the meter movement to bypass current around the meter movement
2. Shunt calculations: $R_s = (R_M \times I_M) / (I_T - I_M)$
3. Ammeter connections
   a. Always connect in series with the circuits being measured
   b. Polarity must be observed to protect the meter movement
   c. Most commercial ammeters have their shunt resistor built in

C. Voltmeters

Show Transparency fig. 72

1. The meter in a voltmeter is actually an ammeter
   a. Voltage is measured by sending current through a known resistance
   b. A scale on the face of the meter is marked in volts
2. Sensitivity
   a. Ohms per Volt - used by manufacturers for sensitivity instead of current
   b. (Full scale voltage) / (full scale current) = Ohms / Volt
3. Multipliers
   a. Resistors added in series with a meter movement to extend its range
   b. Calculate multiplier resistance as a resistance in series with the resistance of the meter movement

4. Meter Conversion - to convert a meter movement into a voltmeter, it is necessary to determine the following
   a. Voltage range the voltmeter will be required to measure
   b. Determine the meter sensitivity (1 mA at 1 V or Ohms/V)
   c. Calculate the multiplier resistor to be used in series with the meter

D. Ohmmeters
Show Transparency fig. 73

1. Parts
   a. Battery - furnishes power to the circuit
   b. Meter movement - indicates current flow in the circuit (Scale is calibrated in Ohms)
   c. Ohms zero adjust - compensates for various battery voltages
   d. Safety resistor - limits current to a safe value for the meter
   e. Leads - used connect meter to unknown resistance to be measured
2. Resistance scale calibration
   a. Leads open - current is zero then resistance is infinite
   b. Leads shorted - current is maximum then resistance will be zero
   c. For resistance values in between - the scale is calibrated with known resistors, and the current value is interpreted as resistance in Ohms
3. Ohmmeter use
   a. The part of the circuit being measured must be disconnected from the rest
   b. Power must be off in the circuit

E. Wheatstone Bridge
Show Transparency fig. 74

1. Provides precise measurement of resistance by balancing an unknown resistance against a standard, accurate resistor
2. Uses a sensitive ammeter called a galvanometer to indicate a balanced condition
3. When balanced, the equal voltage rations will be on the two sides of the circuit
4. Formula: $R_1 / R_2 = R_x / R_4$
   or $R_x = (R_1 \times R_4) / R_2$

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - D.C. Meter Circuits
2. Experiment # 16 - D.C. Voltmeter Multipliers
3. Experiment # 17 - D.C. Ammeter Shunts
4. Experiment # 18 - The Series Ohmmeter
5. Experiment # 19 - The Wheatstone Bridge
6. Check each student's work for completeness and accuracy
7. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - D.C. Meter Circuits
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Magnetism

MOVING-COIL METER CONSTRUCTION

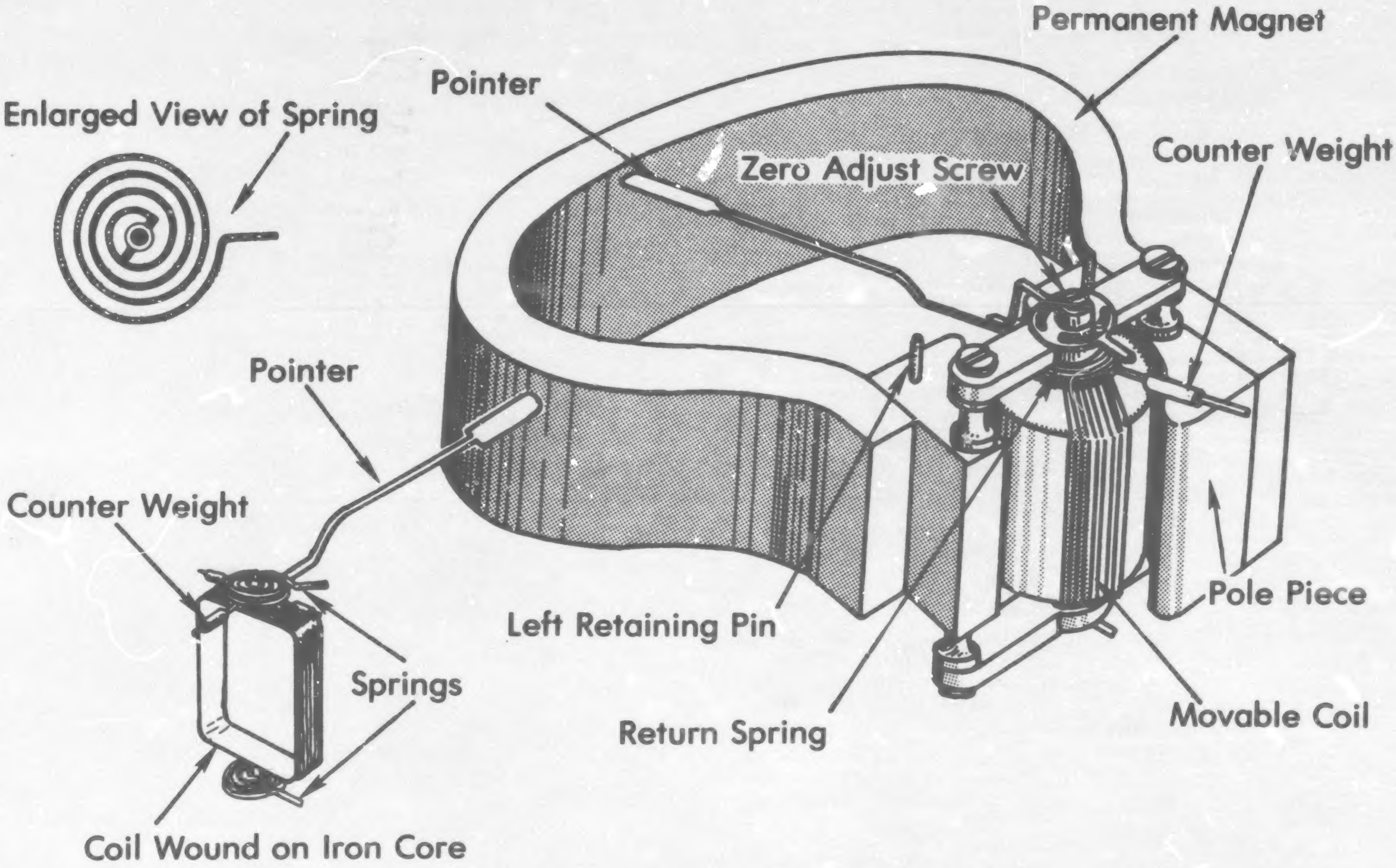

Permanent Magnet
Pointer
Enlarged View of Spring
Zero Adjust Screw
Counter Weight
Pointer
Counter Weight
Pole Piece
Left Retaining Pin
Springs
Movable Coil
Return Spring
Coil Wound on Iron Core

Fig. 70

AMMETER

POINTER MOVEMENT

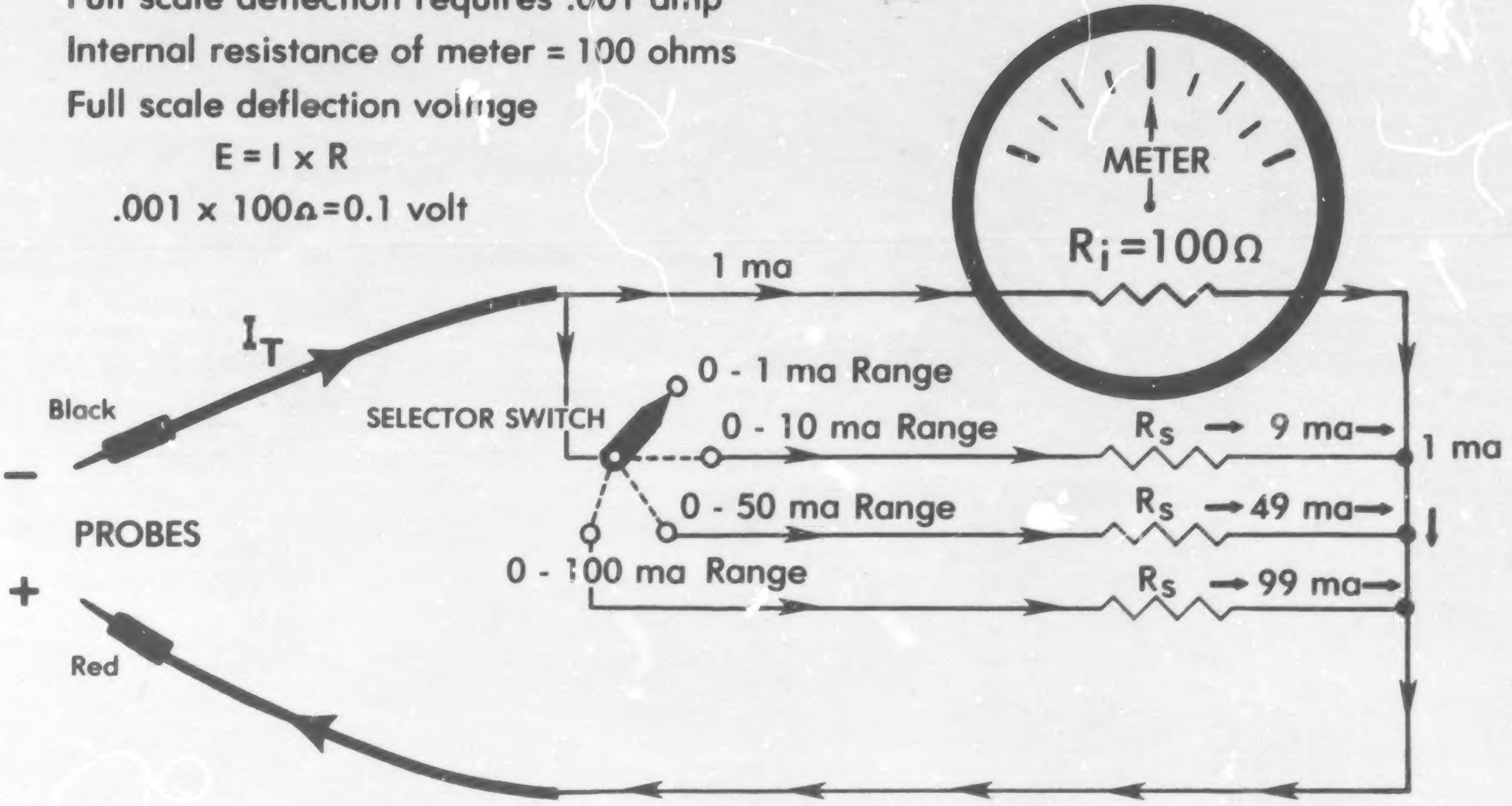
Full scale deflection requires .001 amp

Internal resistance of meter = 100 ohms

Full scale deflection voltage

$$E = I \times R$$

$$.001 \times 100\Omega = 0.1 \text{ volt}$$


METER
$R_i = 100\Omega$
1 ma
I_T
Black
−
PROBES
+
Red
SELECTOR SWITCH
0 - 1 ma Range
0 - 10 ma Range
0 - 50 ma Range
0 - 100 ma Range
R_s → 9 ma →
R_s → 49 ma →
R_s → 99 ma →
1 ma

19500

Fig. 71

VOLTMETER

POINTER MOVEMENT

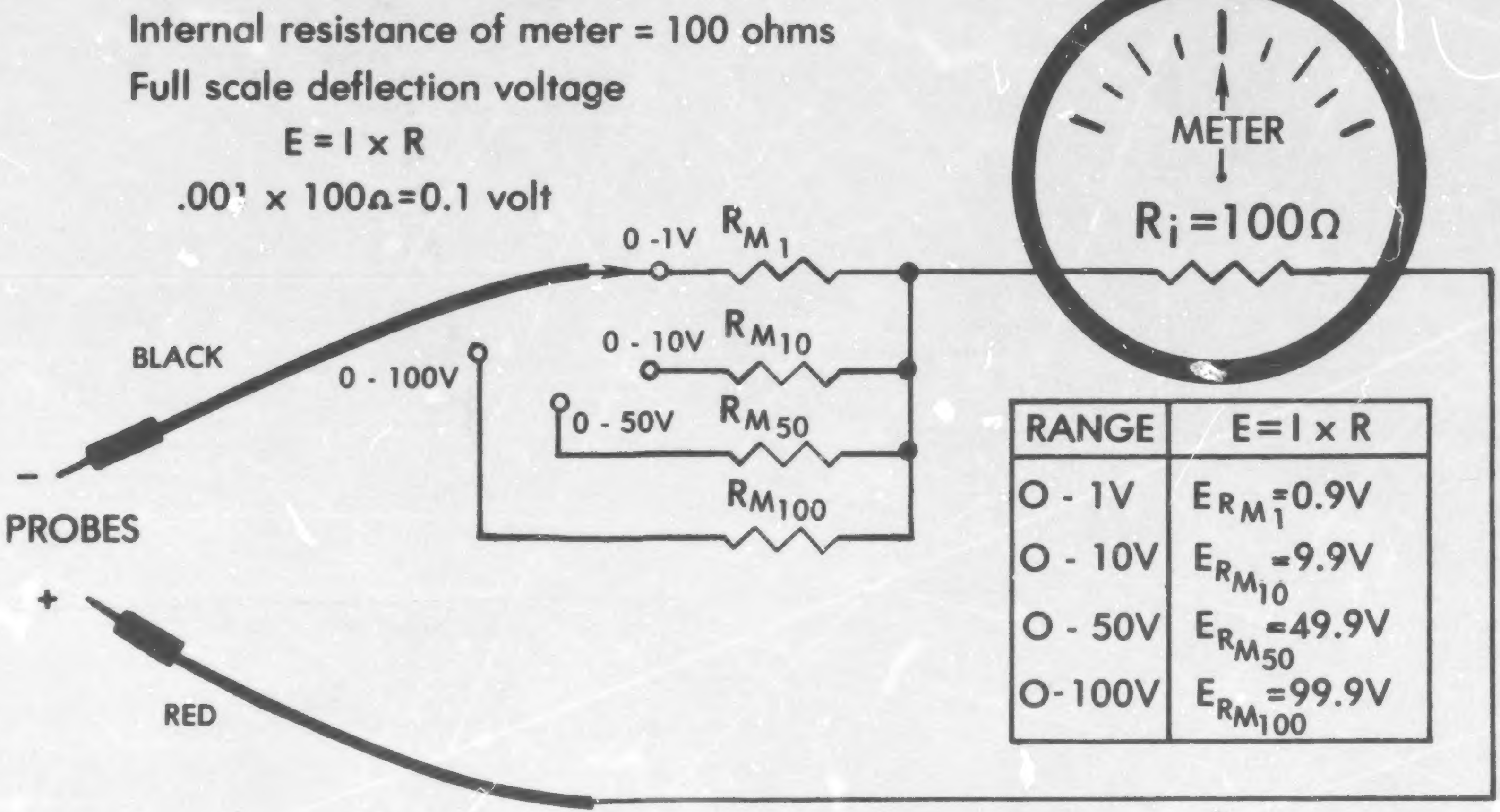
Full scale deflection requires .001 amp

Internal resistance of meter = 100 ohms

Full scale deflection voltage

$$E = I \times R$$

$$.001 \times 100\Omega = 0.1 \text{ volt}$$

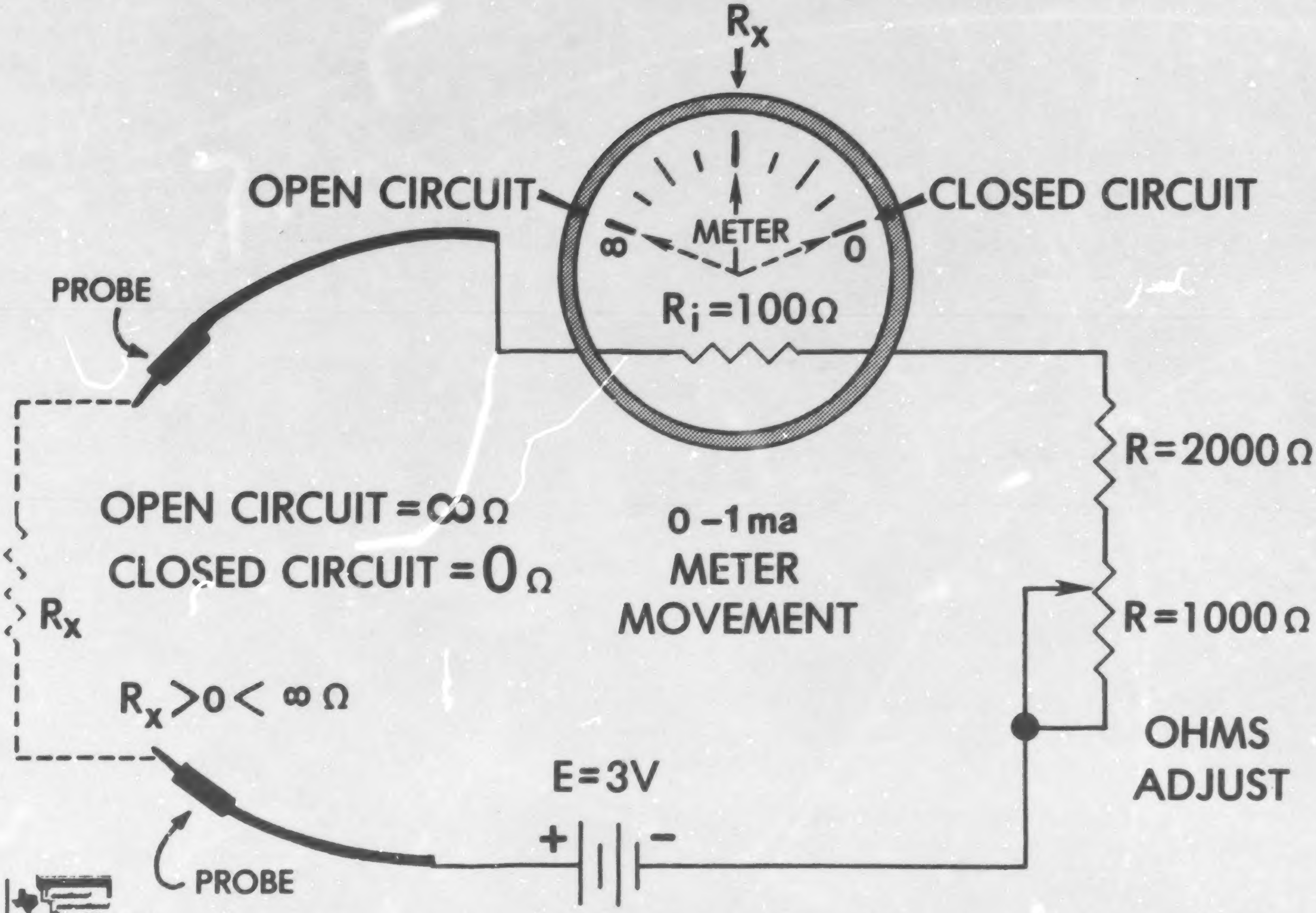

METER
$R_i = 100\Omega$
0 -1V
R_{M_1}
0 - 10V
$R_{M_{10}}$
0 - 50V
$R_{M_{50}}$
0 - 100V
$R_{M_{100}}$
BLACK
−
PROBES
+
RED

RANGE	$E = I \times R$
O - 1V	$E_{R_{M_1}} = 0.9V$
O - 10V	$E_{R_{M_{10}}} = 9.9V$
O - 50V	$E_{R_{M_{50}}} = 49.9V$
O-100V	$E_{R_{M_{100}}} = 99.9V$

$$\text{SENSITIVITY} = \frac{1}{.001} = 1000 \ \Omega/V$$

Fig. 72

Series Type Ohmmeter


R_x
OPEN CIRCUIT
CLOSED CIRCUIT
METER
∞
0
$R_i = 100\Omega$
PROBE
$R = 2000\,\Omega$
$R = 1000\,\Omega$
OHMS ADJUST
R_x
E=3V
+
−
PROBE

OPEN CIRCUIT $= \infty\,\Omega$

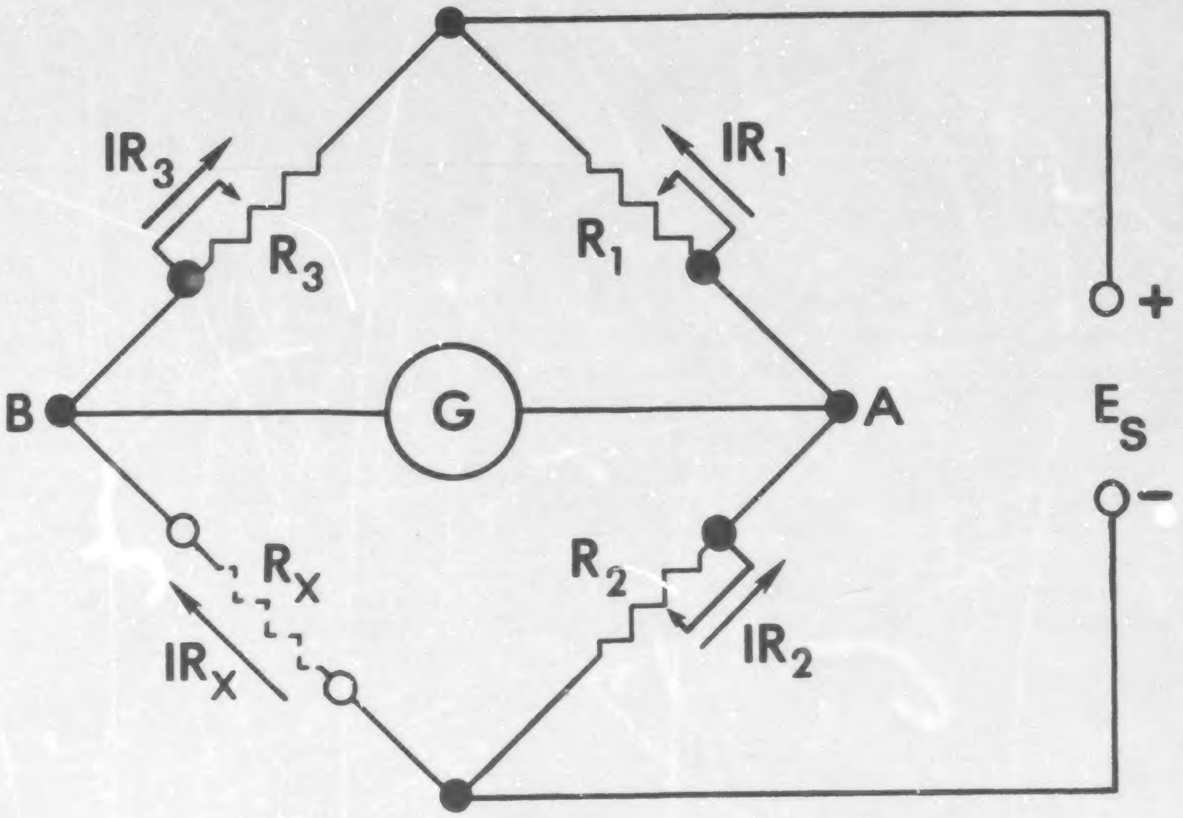
CLOSED CIRCUIT $= 0\,\Omega$

0 – 1 ma METER MOVEMENT

$R_x > 0 < \infty\,\Omega$

BRIDGE CIRCUITS

BALANCED BRIDGE $E_A = E_B$


IR_3
R_3
IR_1
R_1
+
B
G
A
E_S
−
R_X
IR_X
R_2
IR_2

$$E_{R_1} = E_{R_3} \qquad \frac{R_1}{R_2} = \frac{R_3}{R_X}$$

$$E_{R_2} = E_{R_X} \qquad R_X = \frac{R_2 \times R_3}{R_1}$$

D.C. METER CIRCUITS

IV-D-1(AS)
Key

Name ______________________________ Date ________________________

Directions: Read each statement carefully. Select the work or words which best completes each statement and place it in the space provided. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

d'Arsonval 1. The ____ meter movement depends on the interaction between permanent and electromagnets.

Sensitivity 2. The ____ of a meter movement can be expressed as the amount of current required for full-scale deflection.

Shunt 3. A/an ___ resistance is connected across a meter to extend the range for current measurements.

Cannot 4. The sensitivity of a meter movement ___ (can/cannot) be changed.

3.75 m Ohm 5. A meter movement has a sensitivity of 0.05 mA and requires a voltage of 3.75 mV for full-scale deflection. A shunt resistor of ____ is required for a range of 1A.

1.02 Ohms 6. Calculate the shunt required to convert a meter to read 0 to 50 mA when the meter has a sensitivity of 1 mA and a resistance of 50 Ohms.

Multiplier 7. A/an ____ resistor is used to expand the range of a voltmeter.

4.00 K Ohms 8. What value of multiplier resistor is needed to convert a 1 mA - 1 V meter movement to read 5 Volts full-scale?

10.0 K Ohms/V 9. A meter movement requires 100μA at 1 Volt for full-scale deflection. The meter has a sensitivity of ___ Ohms per Volt.

199 K Ohms 10. A 50μA meter movement has a resistance of 1,000 Ohms. What value of multiplier resistance is needed for a voltmeter range of 10 V?

Ohmmeter 11. The ____ indicates resistance by measuring the current flowing through a series circuit.

Battery 12. The ____ in an ohmmeter should be replaced if the meter cannot be zero adjusted.

Live	13. For safety reasons, an ohmmeter must never be used to measure resistance in a/an ____ circuit.
Shorted	14. To conserve batteries, an ohmmeter should not be stored with its probes ____.
1.40 K Ohm	15. A 0-1 mA, 100 Ohm meter movement must have a resistance of ____ and a 1.5 V battery in series with it to be used as a series ohmmeter.
Non-Linear	16. The scale of an ohmmeter is a ____ scale.
Wheatstone	17. An instrument used to accurately measure resistance is the ____ bridge.
Galvanometer	18. A/an ____ is a sensitive current measuring device that will measure current in either direction.
Zero	19. A bridge circuit is balanced when there is ____ current flowing through the measuring device.
Meter Movement	20. A multimeter of VOM accomplishes maximum utilization of a single ____.

TEST

IV-D-1(T)
Key

Name ______________________________ Date ___________________________

Directions: Read each statement carefully. Answer the following questions and solve the problems carefully. Write your answers in the space provided. Use four significant figures and the proper metric prefix for calculated answers. Be sure to check your answers.

d'Arsonval	1. The most commonly used analog meter movement is the ____ movement.
Sensitivity	2. The ____ of a meter movement can be expressed as the amount of current required for full-scale current.
Shunt	3. The range of an ammeter can be extended by using a ____ resistor.
Multiplier	4. A/an ____ resistor is used to expand the range of a voltmeter.
Volt	5. Resistors used to expand the range of ____ meters typically have large resistance values.
Ohmmeter	6. The ____ indicates resistance by measuring the current flowing through a series circuit.
Battery	7. If an ohmmeter cannot be zero adjusted, the ____ should be replaced.
Live	8. For safety reasons, an ohmmeter must never be used to measure resistance in a/an ____ circuit.
Galvanometer	9. A/an ____ is a sensitive current measuring device that will measure current in either direction.
Balanced	10. A bridge is ____ when there is zero current flowing through the measuring device.
1.010 Ohm	11. Calculate the shunt required to convert a 1 mA, 100 Ohm meter to read 100 mA full scale.
5.025 Ohms	12. A 50 μA meter movement has an internal resistance of 1,000 Ohms. What shunt value is needed for a current range of 10 mA?
18.00 K Ohms	13. For a 1.00 Volt range, a 50 μA meter movement with an internal resistance of 2,000 Ohms requires a multiplier resistance of ___.

29.95 K Ohms 14. With a 50 Ohm, 1 mA meter movement, calculate the multiplier resistance needed for a range of 30.0 V.

False 15. The sensitivity of a meter movement can be changed using resistors. (True/False)

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON
V-A-1(I)

SUBJECT: Magnetism

AIM: Upon successful completion of the lesson, the student will be able to demonstrate an understanding of permanent and electromagnets as applied to electronics through experimentation and answering questions.

TEACHING AIDS: Chalkboard, overhead projector, Transparencies 19500, figs. 75-83

MATERIALS:
- Assignment Sheet - Magnetism
- Experiment # 21 - Permanent Magnets
- Experiment # 22 - Electromagnets
- Experiment # 23 - Electromagnetism
- Test Sheet - Magnetism

TOOLS AND EQUIPMENT: Student lab station, component set

REFERENCES:
Fowler, Electricity - Principles and Applications
Grob, Basic Electronics

PREREQUISITE EXPERIENCE OF THE LEARNER: All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Magnets have many uses in electronics. Every motor and generator requires a magnetic field for operation. Magnetism is found in practically every electronic application. Electricity and magnetism cannot be separated. Whenever an electric current exists, a magnetic field also exists. Magnetism operates many devices such as transformers, relays and loudspeakers. After completing this lesson, you will be able to demonstrate an understanding of permanent and electromagnets as applied to electronics.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Magnetism Show Transparency fig. 75	1. Magnetism is an invisible force field that acts on some materials but not on others 2. Magnetic fields extend in all directions from the magnet 3. Magnetic flux - invisible lines of force which make up field

B. Magnetic Poles

Show Transparency fig. 76

1. North pole - end of magnet which will seek the earth's south magnetic pole
2. South pole - the other end of the magnet

Show Transparency fig. 77

3. Flux direction - lines run from the north pole to the south pole

Show Transparency fig. 78

4. Law of magnetic poles - like poles repel and unlike poles attract

C. Magnetic Materials

Show Transparency fig. 79

1. Lodestone (magnetite) - an iron compound and natural magnet
2. Ferro magnetic materials - (ferro means iron) most magnetic materials contain iron
3. Artificial magnetic materials:
   a. ALNICO (aluminum-nickel-cobalt)
   b. Ferrite - ceramic material
4. Non-magnetic materials:
   a. Most metals - brass, copper, aluminum, etc.
   b. Wood, paper, glass, etc.
   c. Flux goes through non-magnetic materials like air

D. Domain Theory

Show Transparency fig. 80

1. Magnetic domains (dipoles) are small magnetic like structures within the material
2. Random arrangement when material is not magnetized
3. Domains are aligned when material is magnetized
4. Permanent magnets - domains stay aligned
5. Temporary magnets - domains go back to random order

E. Electromagnets

1. Magnetism created by electric current
2. Magnetic field around a conductor
   a. Field is always at right angles to current path
   b. Field is continuous for the length of the conductor

Show Transparency fig. 81

   c. Left hand rule for flux direction:
      1.) Grasp conductor with left hand
      2.) Thumb should be in direction of current
      3.) Fingers will indicate direction for flux
3. Strength of magnetic field is determined by the amount of current
4. Force between parallel conductors
   a. Current in the same direction causes attraction because fields join together

b. Current in opposite directions causes repulsion between conductors

Show Transparency fig. 82

5. Coils - several conductors side by side increases magnetic field. Makes big electromagnet

Show Transparency fig. 83

6. Coil magnetic polarity - left hand rules:
   - a. Wrap fingers around coil in direction of current flow
   - b. Thumb points to north pole
7. Coil magnetic strength depends on how close the wire is placed to each other, amount of current flow through the coil and the number of turns on the coil

F. Terms

1. Core - magnetic material placed in the center of a coil, (usually to concentrate the magnetic flux)
2. Magnetomotive force - effort exerted in creating a magnetic field (mmf)
3. Saturation - when a core material is "full" and increasing the mmf will not increase the field
4. Residual magnetism - the flux that remains in a temporary magnet after it is removed from a magnetic field
5. Retentivity - ability of a material to remain magnetized
6. Reluctance - opposition to magnetic flux
7. Magnetic shields - low reluctance materials which are put around an object to keep the flux from affecting it
8. Ampere-turns - basic unit of magnetomotive force
9. Permeability - a measure of the ease with which magnetic flux will pass through a material
10. Induction - magnetizing a material using a magnetic field
11. Induced voltage - when a conductor moves through magnetic flux, a voltage is induced across it. (Amount depends on amount of flux and speed of cutting)

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Magnetism
2. Experiment # 21 - Permanent Magnets
3. Experiment # 22 - Electromagnets
4. Experiment # 23 - Electromagnetism
5. Check each student's work for completeness and accuracy
6. Answer any student questions

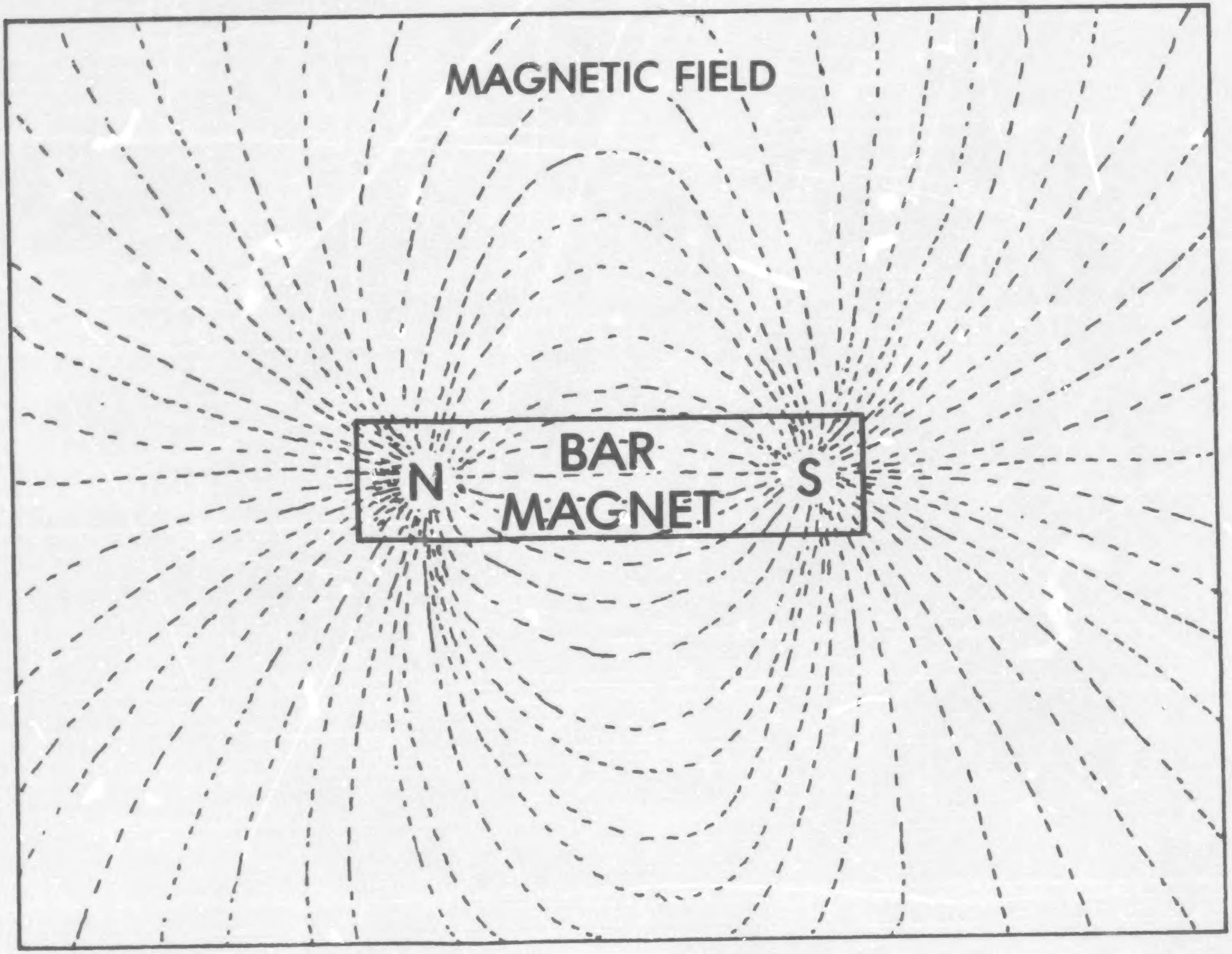
IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - Magnetism
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

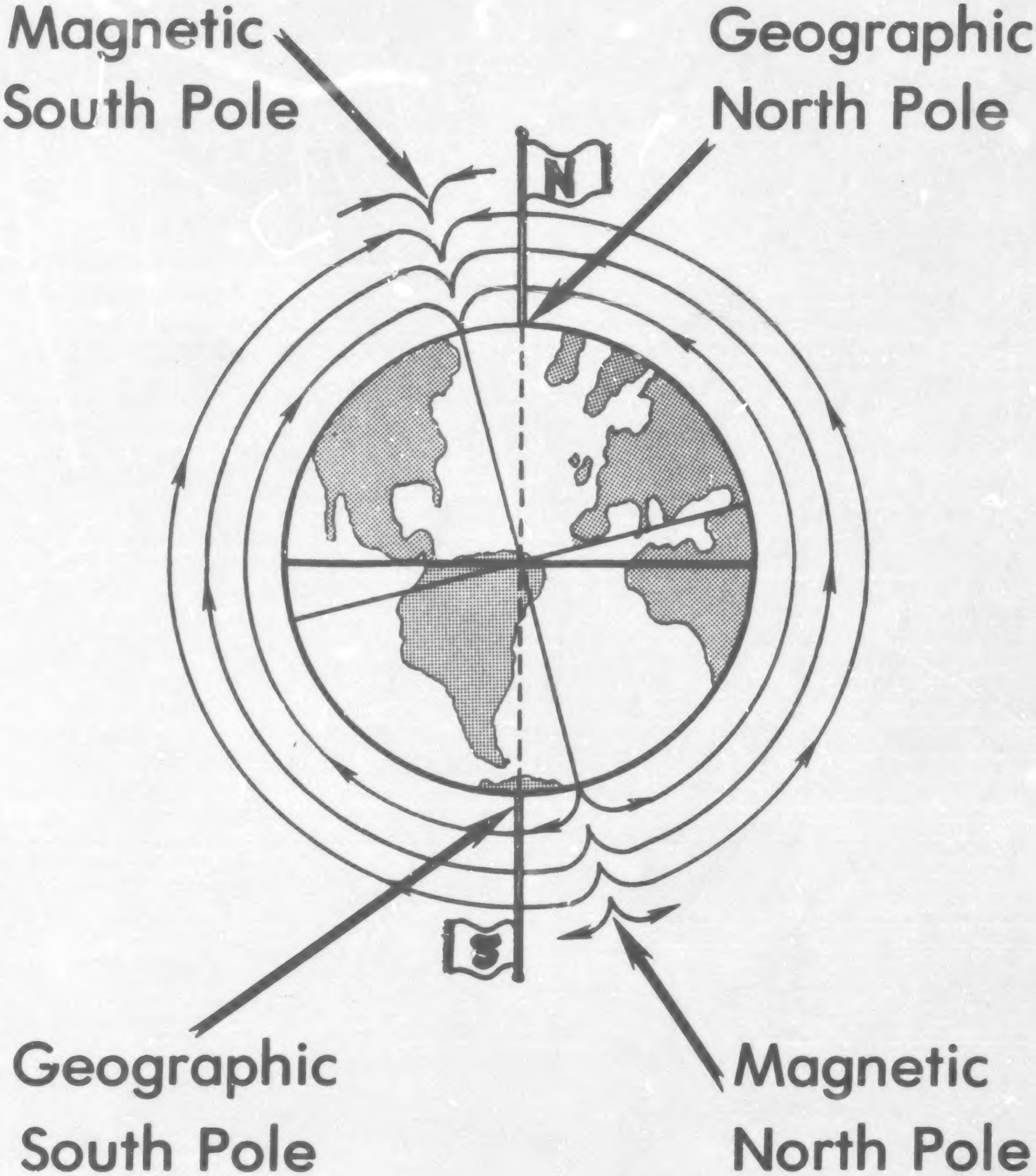
THE NEXT LESSON IS: Electromagnetic Devices


MAGNETIC FIELD
N
BAR
MAGNET
S

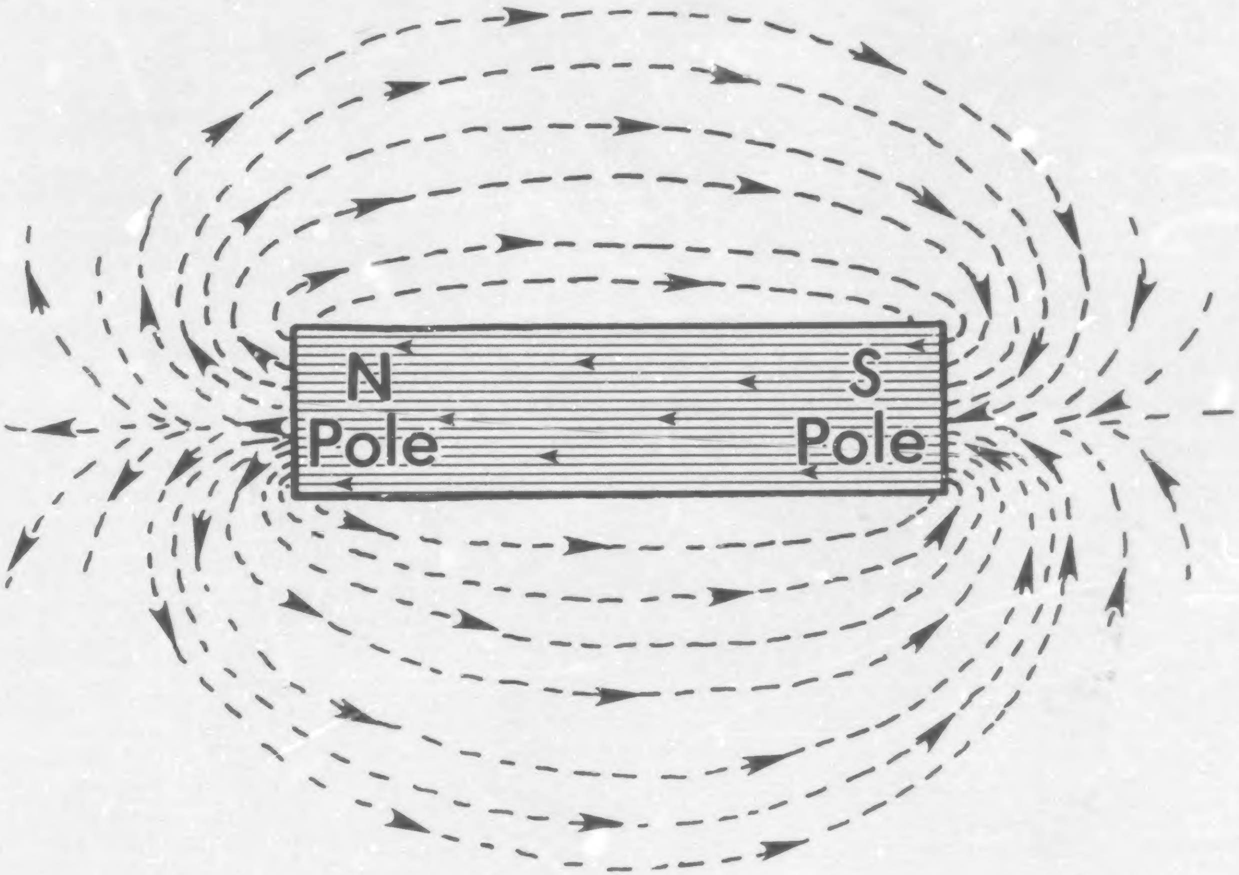
19500

Fig. 75

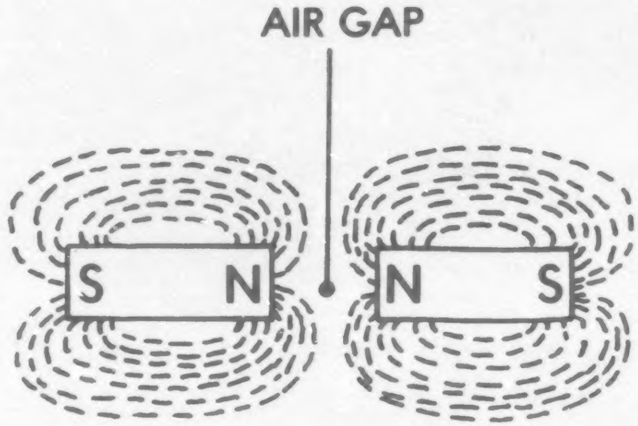
MAGNETIC POLES


Magnetic South Pole
Geographic North Pole
N
S
Geographic South Pole
Magnetic North Pole

FLUX DIRECTION or LINES OF FORCE

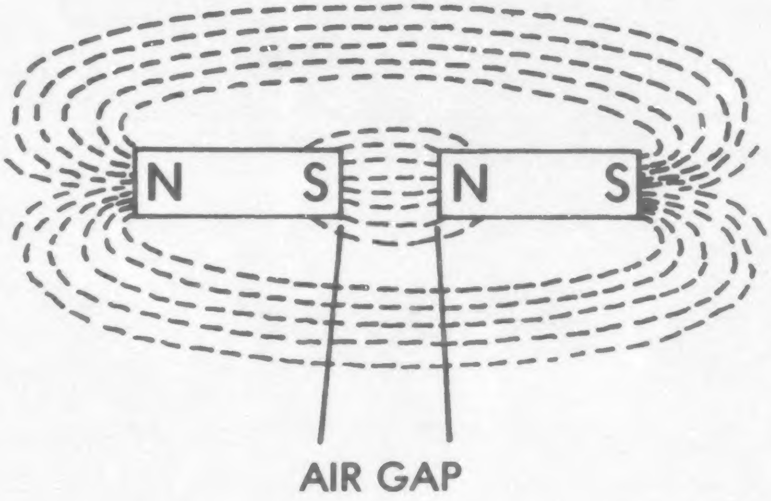

N
Pole
S
Pole

LAW OF MAGNETIC POLES

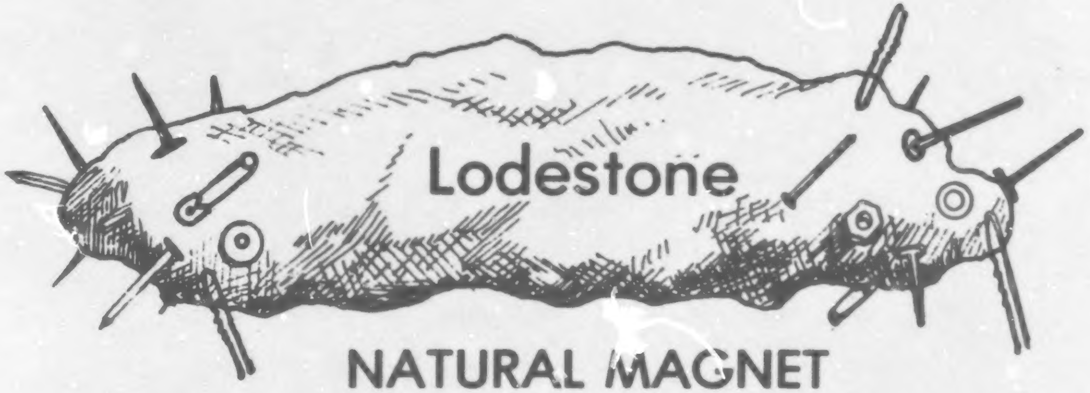

AIR GAP
S
N
N
S

Like Poles Repel

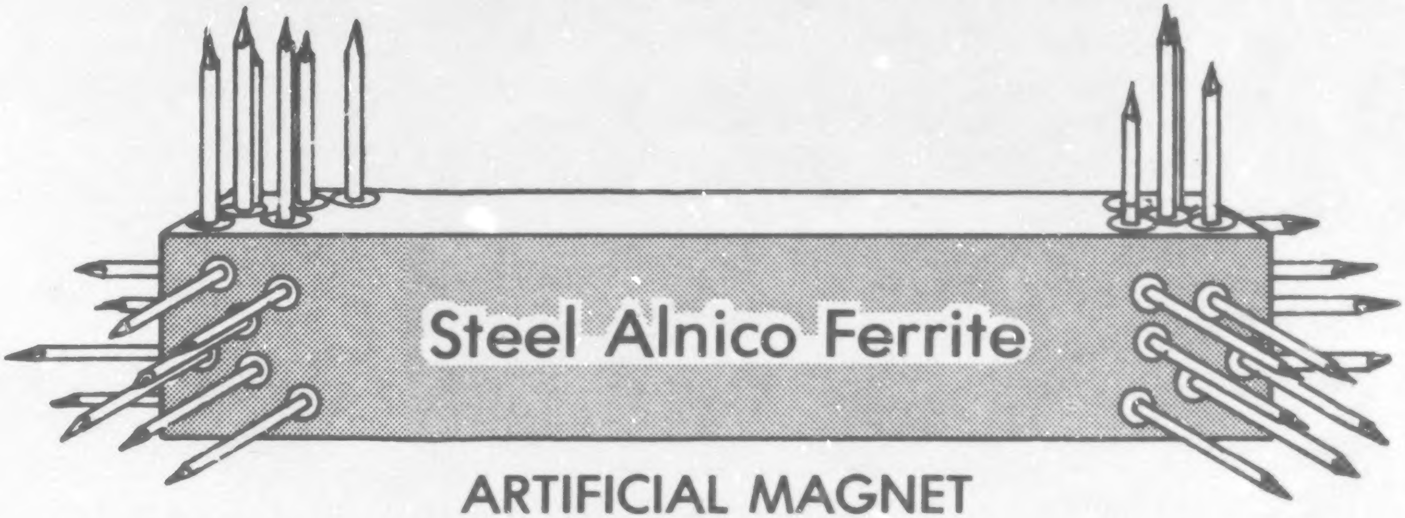
Unlike Poles Attract


N
S
N
S
AIR GAP

MAGNETIC MATERIALS



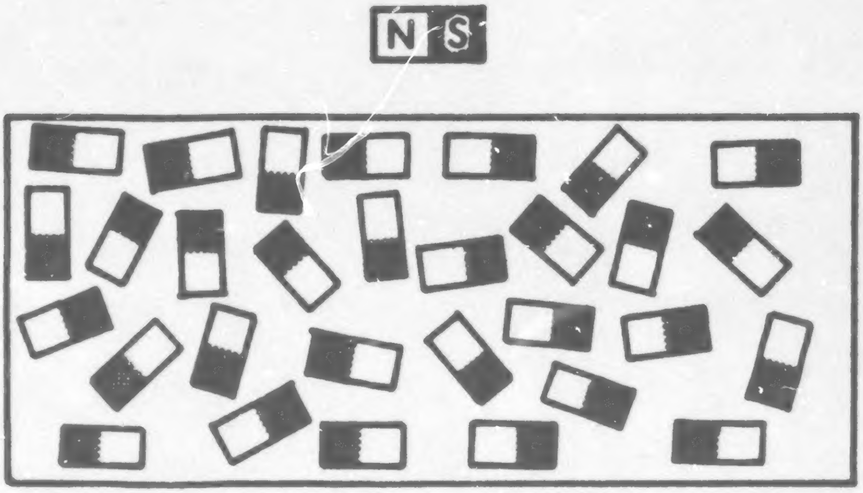
NATURAL MAGNET


Steel Alnico Ferrite

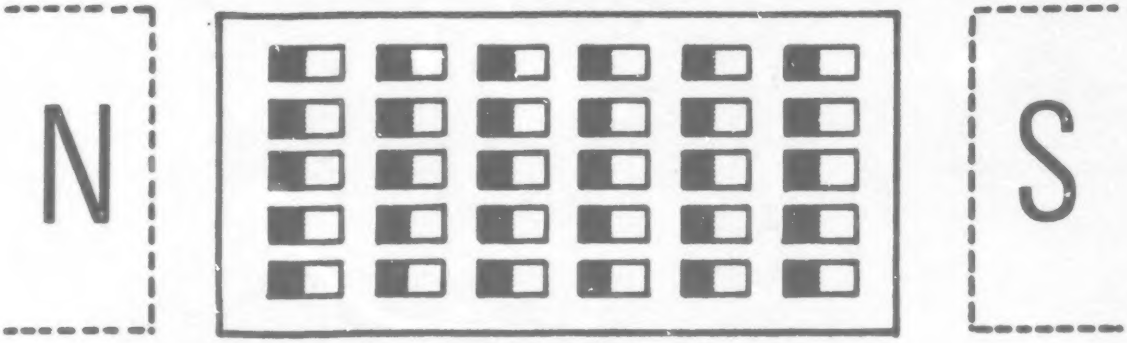
ARTIFICIAL MAGNET

Fig. 79

MAGNETIC DOMAIN THEORY

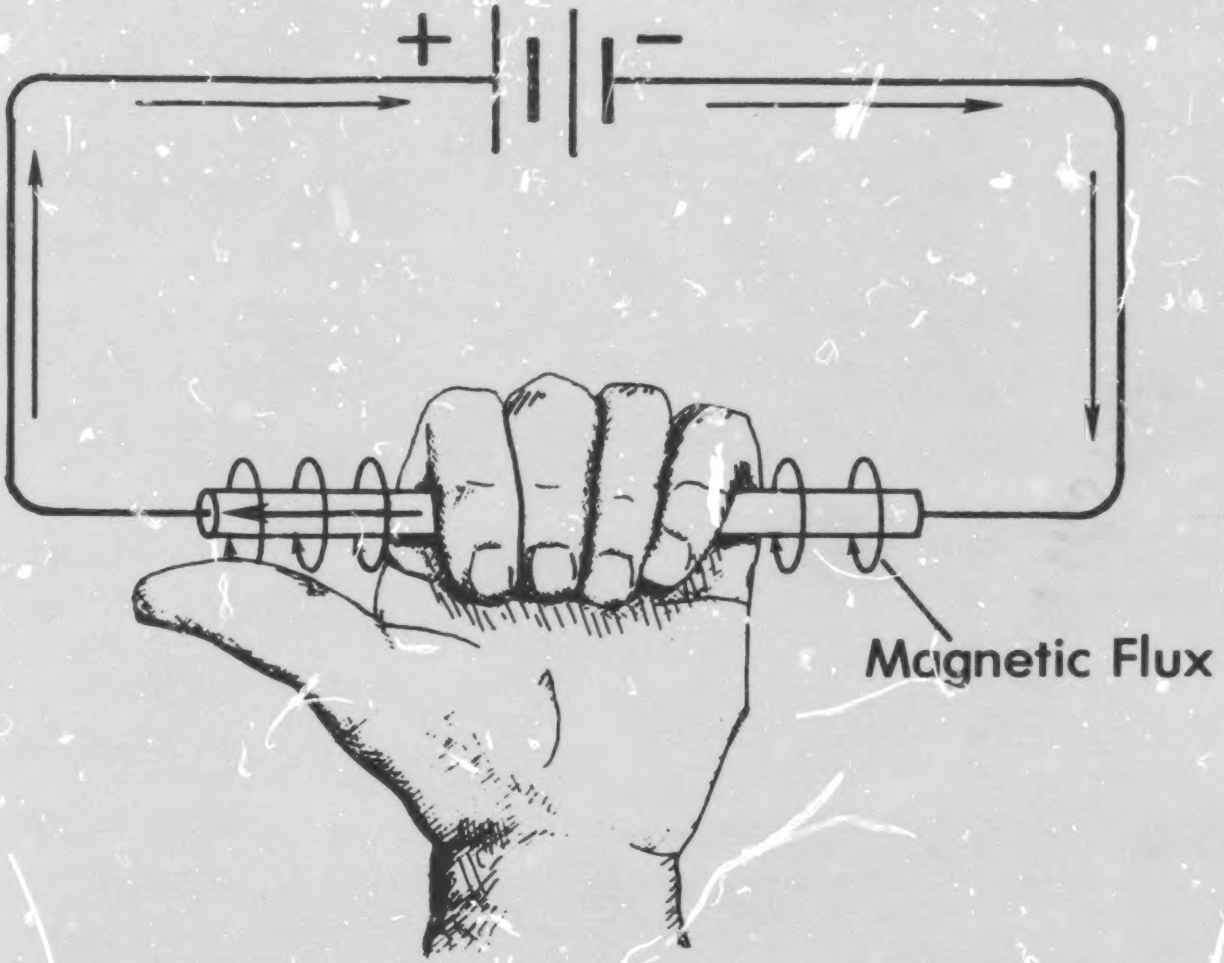


IRON NOT MAGNETIZED



MAGNETIZED IRON

MAGNETIC FIELD AROUND A CONDUCTOR


+
−
Magnetic Flux

LEFT-HAND RULE DETERMINES DIRECTION OF FLUX LINES

MAGNETIC FIELD AROUND A COIL

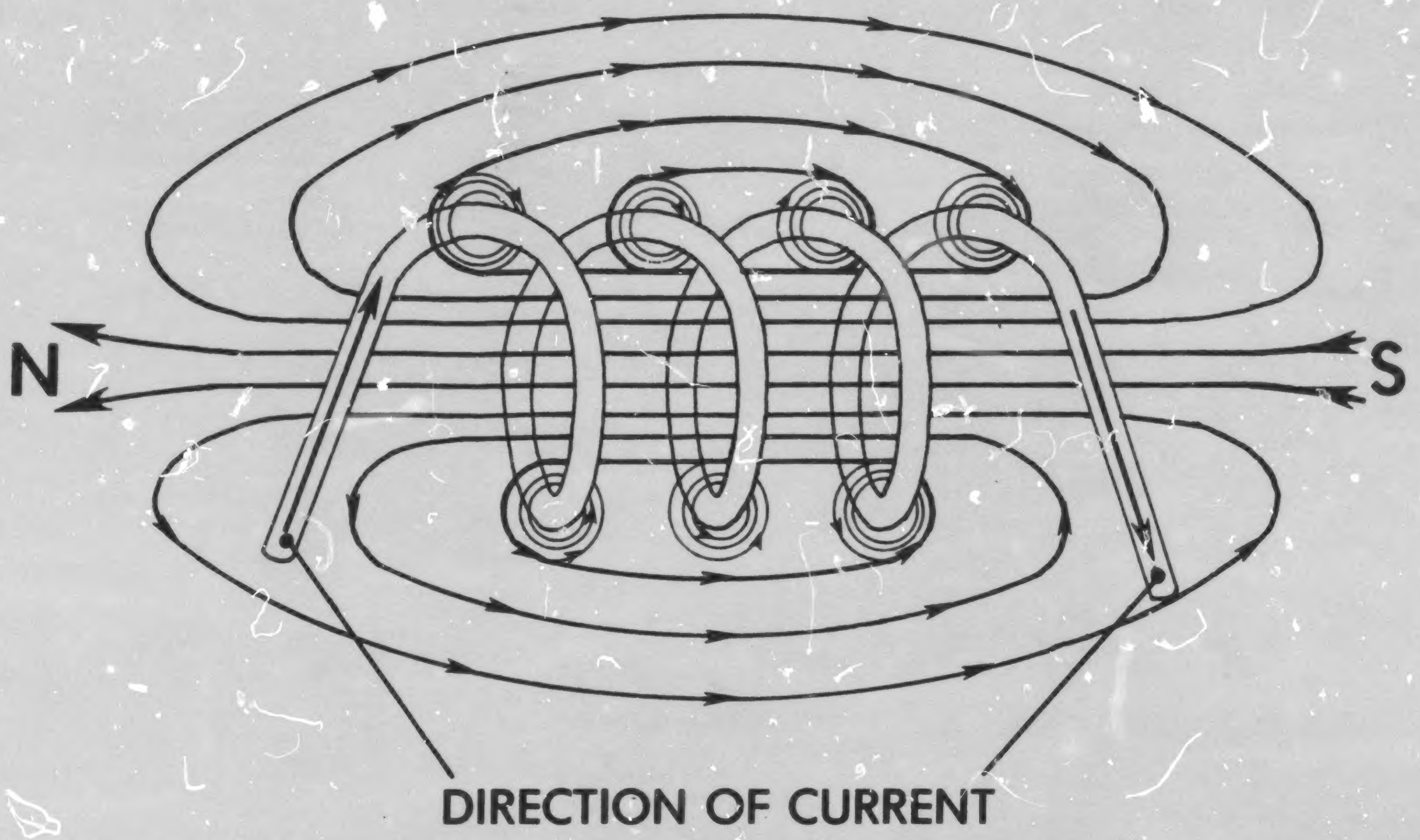
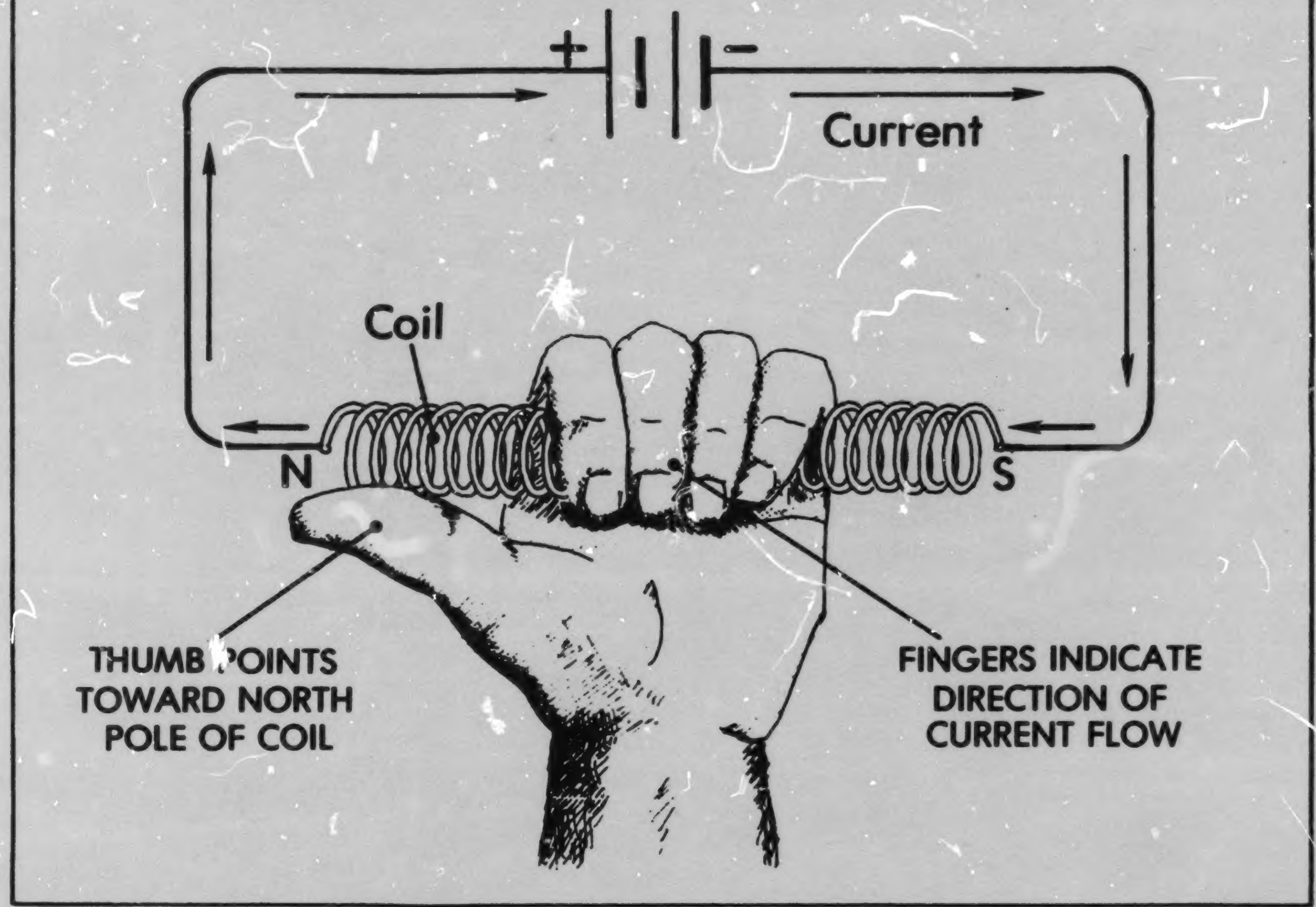

N
S
DIRECTION OF CURRENT

Fig. 82

LEFT-HAND RULE FOR A COIL


+
–
Current
Coil
N
S

THUMB POINTS TOWARD NORTH POLE OF COIL

FINGERS INDICATE DIRECTION OF CURRENT FLOW

MAGNETISM

V-A-1(AS)
Key

Name ____________________ Date ____________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

Field 1. Magnetism is an invisible force ____ which exists around a magnet.

Flux 2. The lines of force of a magnetic field are called magnetic ____.

North-South 3. The direction of flux is from the ____ to the ____ pole of a magnet.

Left hand 4. The ____ rule is used to determine the direction of flux around a conductor carrying current.

Attract 5. Two parallel conductors will ____ each other if their currents are in the same direction.

Ferromagnetic 6. A magnetic material containing iron is sometimes called a/an ____ material.

Stop 7. Nonmagnetic materials do not ____ flux from passing through them.

Domains 8. The ____ within a permanent magnet will remain aligned after removal from the magnetizing force.

Magnetomotive 9. The effort exerted in creating a magnetic field is called ____ force.

Saturation 10. When a core material is ____, increasing the magnetomotive force will not increase the flux.

Residual 11. The flux that remains in a temporary magnet when the magnetizing field is removed is called ____ magnetism.

Reluctance 12. The opposition within a material to magnetic flux is ____.

Retentivity 13. The ability of a material to retain magnetism is called ____.

Ampere-turns 14. The basic unit of magnetomotive force is ____.

Permeability 15. The ease with which magnetic flux will pass through a material is ___.

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

T 16. Magnetic flux is assumed to leave a north pole and enter a south pole.

T 17. Magnetic lines of flux are continuous loops.

F 18. Non-magnetic materials have orderly arranged domains.

F 19. Permanent magnet materials have very little residual magnetism.

T 20. Permeability refers to the ability of a material to carry magnetic flux.

V-A-1 (T)
Key

TEST

Name ______________________ Date ______________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers.

Flux	1. The lines of force of a magnetic field are called magnetic ____.
North	2. Magnetic flux exits a magnet from the ____ pole of a magnet.
Field	3. Magnetism is an invisible force ____ which exists around a magnet.
Left hand	4. The ____ rule is used to determine the direction of flux around a conductor carrying current.
Iron	5. A material containing ____ is called a ferromagnetic material.
Domains	6. The ____ within a permanent magnet will remain aligned after removal from the magnetizing force.
Magnetomotive	7. The effort exerted in creating a magnetic field is called ____ force.
Saturation	8. When a core material is ____, increasing the magnetomotive force will not increase the flux.
Residual	9. The flux that remains in a temporary magnet when the magnetizing field is removed is called ____ magnetism.
Reluctance	10. The opposition within a material to magnetic flux is ____.
Retentivity	11. The ability of a material to retain magnetism is called ____.
Permeability	12. The ease with which magnetic flux will pass through a material is ____.
Force	13. Ampere-turns is the basic unit of magnetomotive ____
North	14. The end of the compass needle pointing to the north geographic pole is the ____ pole of the magnetic needle.
Shields	15. Materials with low reluctance are called magnetic ____.

V-A-1(T)
Key

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

T 16. Magnetized materials have orderly arranged domains.

F 17. Permanent magnet materials have very little residual magnetism.

T 18. Permeability refers to the ability of a material to carry magnetic flux.

T 19. Magnetic flux is assumed to leave a north pole and enter a south pole.

T 20. Magnetic materials can be magnetized by putting them in the fields of magnets.

INSTUCTOR'S PLAN
INFORMATIONAL LESSON

V-B-1(I)

SUBJECT: Electromagnetic Devices

AIM: Upon successful completion of this lesson, the student will be able to explain and demonstrate the operating principles of electromagnetic devices.

TEACHING AIDS: Chalkboard, overhead projector, Transparencies 19500, figs. 84-85

MATERIALS:
Assignment Sheet - Electromagnetic Devices
Experiment # 26 - Generator Principles
Experiment # 27 - Relays
Test Sheet - Electromagnetic Devices

TOOLS AND EQUIPMENT: Student lab station, component set

REFERENCES:
Fowler, Electricity - Principles and Applications
Grob, Basic Electonics

PREREQUISITE EXPERIENCE OF THE LEARNER: All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

In the last lesson we learned about magnetism and its relationship with electricity. After sucessfully completing this lesson, you will be able to demonstrate how magnetism is used to produce and control electricity and how electricity is used to produce and control magnetism in electromagnetic devices.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Generator Principles Show Transparency fig. 84	1. Methods of generating electricity a. Coil passing through magnetic field b. Magnetic field passing through coil 2. Factors controlling voltage a. Number of lines of force being cut b. Speed of coil 3. One volt produced by one wire cutting 100,000,000 lines of force in one second 4. Methods of increasing voltage a. Add more conductors b. Increase speed

5. Loop ends connected to commutator bars on DC generators and slip rings on AC generator
6. Graphite brushes make connection to outside circuit

B. Generator Types

1. Permanent magnet generators
2. Field coil generators

C. Electric Motor Principles

1. Reverse of generator action
2. Current through armature produces magnetic field which opposes field magnet causing rotational force called torque
3. Field poles are often electromagnets

D. Electric Motor Types

1. Permanent magnet motors
   - a. Permanent magnets form stationary field
   - b. Electromagnetic field rotates
   - c. Polarity changes causes repulsion between fields
   - d. Repulsion makes armature rotate
2. Series DC motors
   - a. Field coil and armature coil wired in series
   - b. One path for current
   - c. Can be started under heavy load
   - d. Counter emf increases with speed reducing torque
3. Shunt DC motors
   - a. Field and armature coils connected in parallel
   - b. Current has two distinct paths
   - c. Constant speed
4. Universal motors
   - a. Runs on AC or DC current
   - b. Coils connected in series
   - c. Direction of current flow does not change direction of rotation
5. Induction motors
   - a. Contain stationary starter and rotating member
   - b. Run on either three phase or single phase AC
   - c. Three phase will start automatically
   - d. Single phase must have starting mechanism
     - 1.) Phase splitting
     - 2.) Repulsion
     - 3.) Pole shading

II. PRESENTATION (CONT'.) V-B-1(I)

E. Solenoids Show Transparency fig. 85	1. Electromechanical device that enables an electric current to control a mechanical device 2. De-energized solenoid in normal condition has no magnetic force to hold plunger 3. When energized, plunger is moved by magnetic field
F. Relays	1. Similar to solenoid operated switch 2. Normal position has no current flow through coil 3. Many switch arrangements are available 4. Many coil ratings (voltage) are available
G. Speakers	1. Movements of cone controlled by magnetic field produced by current flowing through interaction with permanent magnet 2. Ratings are usually power, impedance, and frequency response 3. Converts electrical energy into mechanical (sound) energy
H. Magnetic Reed Switches	1. Usually SPST which are controlled using a magnetic field 2. Magnet attracts parts of switch and causes the switching action

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Electromagnetic Devices
2. Experiment # 26 - Generator Principles
3. Experiment # 27 - Relays
4. Check each student's work for completeness and accuracy
5. Answer any students questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

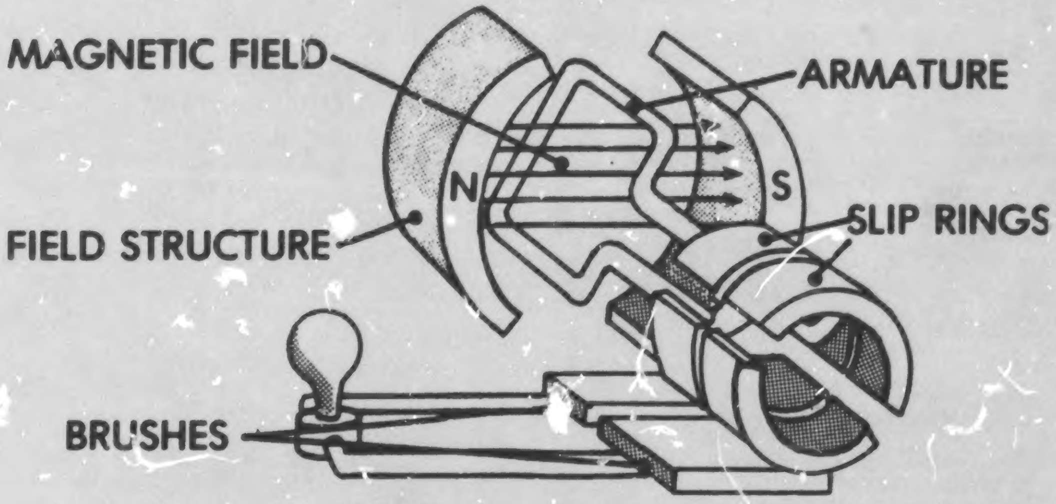
1. Ask oral questions
2. Test Sheet - Electromagnetic Devices
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

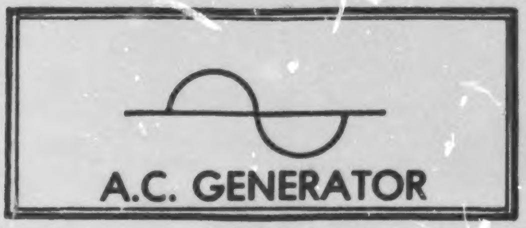
1. Review the major topics of the lesson
2. Discuss test and answer student questions

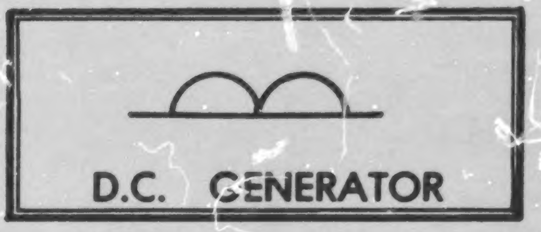
THE NEXT LESSON IS: Alternating Current

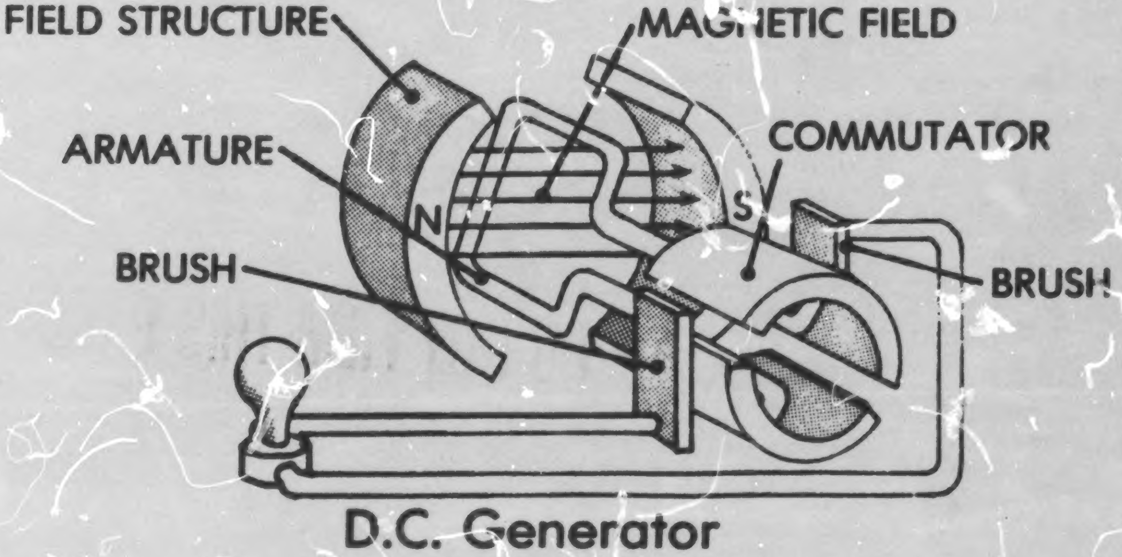
A.C. and D.C. GENERATORS


MAGNETIC FIELD
ARMATURE
N
S
FIELD STRUCTURE
SLIP RINGS
BRUSHES

A.C. Generator

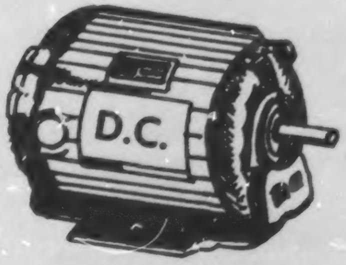

A.C. GENERATOR


D.C. GENERATOR

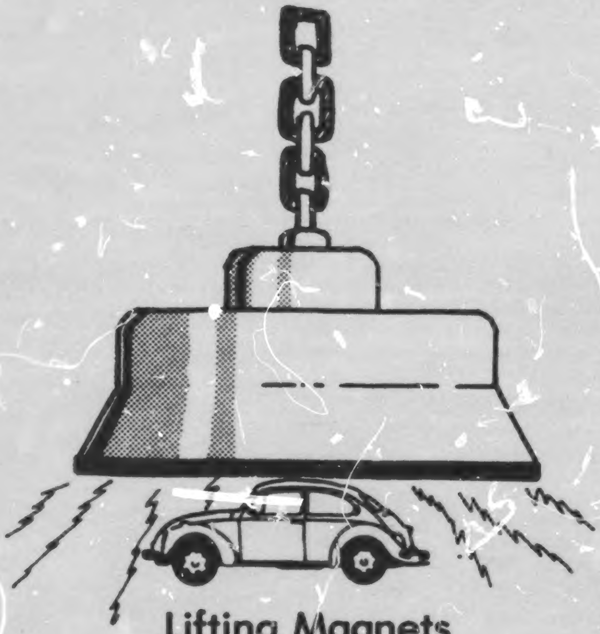

FIELD STRUCTURE
MAGNETIC FIELD
ARMATURE
COMMUTATOR
N
S
BRUSH
BRUSH

D.C. Generator

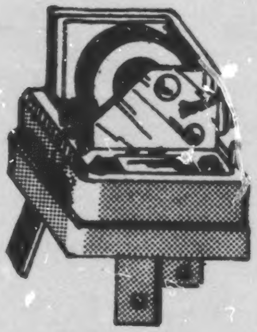
ELECTROMAGNETIC DEVICES



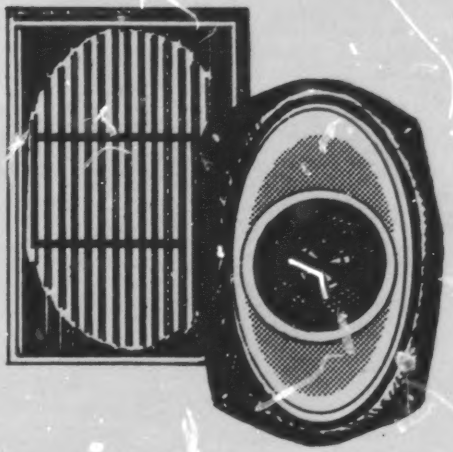
Small D.C. Motors



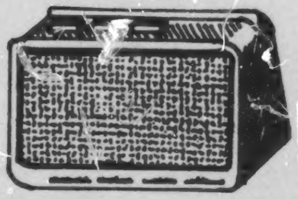
Lifting Magnets



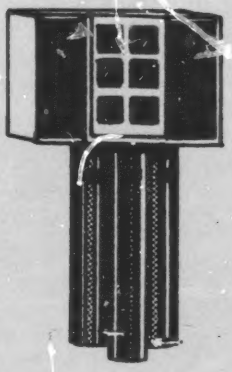
Relays



Speakers



Phone Amplifiers



Door Bells

ELECTROMAGNETIC DEVICES **V-B-1(AS)**
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space on the left. Be sure to check your answers. If you have any questions, ask your instructor.

Magnetic 1. The most common method of producing electricity is by passing a coil through a ____ field.

Speed 2. One factor that controls generated voltage is the ____ of the coil.

Voltage 3. Adding more conductors to a coil increases ____ output.

DC 4. Commutators are used on ____ generators.

Graphite 5. Generator brushes are made of ____.

Field 6. Generators may be either permanenet magnet or ____ coil types.

Reverse 7. Electric motor action can be described as a generator in ____.

Polarity 8. In permanent magnet motors, repulsion is caused by changes in ____.

Rotate 9. Repulsion in permanent magnet motors causes the armature to ____.

Coils 10. In series DC motors the ____ are wired in series.

Series 11. A ____ DC motor can be started under heavy loads.

Shunt 12. An advantage of the ____ DC motor is its constant speed.

Universal 13. Motors that run on either AC or DC are termed ____.

AC 14. Slip rings are used in ____ generators.

Torque 15. Turning or twisting force is termed ____.

SPST 16. Magnetic reed switches are usually of the ____ type.

Mechanical 17. Speakers convert electrical energy into ____ energy.

Starting 18. Single phase induction motors must have a ____ mechanism.

Plunger 19. When energized, a solenoid _____ is moved.

Armature 20. When energized, a DC motor _____ turns.

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

T 21. Series DC motors have one path for the current.

T 22. The coils of universal motors are wired in series.

F 23. The direction of armature rotation is reversed if a universal motor is changed from AC to DC.

F 24. The use of relays is limited due to the few switch arrangements available.

F 25. Phase splitting is used to start series DC motors.

TEST

V-B-1(T)
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the blank on the left. Be sure to check your answers.

Coil 1. The most common method of producing electricity is by rotating a ____ through a magnetic field.

Rotation 2. One of the factors that controls generator output is speed of coil ____.

Brushes 3. Graphite is used to make generator ____.

Commutators 4. In comparing AC and DC generators, slip rings do the same job as ____.

Coil 5. Voltage output can be increased by adding more loops to the ____.

AC 6. Slip rings are used on ____ generators.

Permanent 7. Generators may be either field coil or ____ magnet.

Solenoid 8. A plunger is moved in a ____ by an electromagnetic field.

Polarity 9. Repulsion is caused by ___ changes in permanent magnet motors.

Reverse 10. Generator action can be described as an electric motor in ____.

In series 11. In series DC motors the coils are wired ____.

DC 12. Commutators are found in ____ generators.

Twisting
Turning 13. Torque can be described as ____ or ____ force.

Relay 14. High voltage current can be controlled safely and economically with a ____ circuit.

Current 15. Series DC motors have one path for the ____.

V-B-1(T)
Key

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

F 16. Magnetic reed switches are usually the DPDT type.

T 17. Its armature will still turn in the same direction if a universal motor is changed from DC to AC.

T 18. Phase splitting, repulsion, and pole shading are used to start induction motors.

T 19. In series DC motors, counter emf increases with speed.

T 20. Field and armature coils are connected in parallel in shunt DC motors.

VI-A-1(I)

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT:	Alternating Current
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate knowledge of AC voltage and current by answering questions, making oscilloscope measurements, and performing related calculations.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, figs. 86-92
MATERIALS:	Information Sheet - Alternating Current Assignment Sheet - Alternating Current Task Sheet - Oscilloscope Experiment # 24 - The Oscilloscope Experiment # 25 - Direct and Alternating Current Test Sheet - Alternating Current
TOOLS AND EQUIPMENT:	Student lab station, component set, oscilloscope
REFERENCES:	DeVito, Introduction to Electricity and Electronics Fowler, Electricity - Principles and Applications Gilmore, Instruments and Measurements Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

In this lesson you are going to learn the principles of alternating current by learning the characteristics of a sine wave. You will learn to calculate frequency, time and wavelength. Also you will learn to use the oscilloscope to look at and measure AC voltage waves. This will also provide an accurate method of measuring voltage and time associated with AC.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TODO OR SAY
A. Definition	1. Alternating current (AC) is a current that periodically changes the direction in which it is flowing
	2. Alternating current voltage (AC Voltage) is the voltage which causes alternating current

3. Alternating current power (AC Power) is the power produced by alternating current and voltage

B. Wave Shapes
Show Transparency fig. 86

1. Waveforms are represented by a line on a graph
2. Plotted points represent the value of some electrical quantity at different times
3. Magnitude and direction (voltage and current) are indicated on the vertical axis
4. Time is indicated on the horizontal axis
5. Shapes:
    a. Fluctuating direct current
    b. Pulsating direct current
    c. Sine wave alternating current
    d. Square wave alternating current
    e. Sawtooth wave alternating current

C. Quantities
Show Transparency fig. 87

1. Cycle - the part of a wave which does not repeat itself
2. Positive alternation of half cycle - the portion of the cycle above the zero reference line
3. Negative alternation of half cycle - the portion of the cycle below the zero reference line
4. Period (t) - the time required to complete one cycle of the wave
5. Frequency (f) - the rate at which cycles of a wave are produced
    a. Unit: Hertz, Hz equals one cycle per second
    b. Formula: $f = 1/t$
6. Amplitude - voltage or current value for an AC wave
    a. Peak - the value from the zero reference line to either the positive or negative maximum value
    b. Peak-to-Peak - the value from the positive peak to the negative peak. Equal to twice the peak value
    c. Average - the sum of the instantaneous values of all points in a sine wave is zero. The average value of one alternation is .637 x peak value
    d. Effective or RMS - (root mean squared) - The value which will produce the same heating effect as an equal amount of DC. Equals .707 x peak value

D. Wavelength

1. Length of a complete wave
2. Wave velocity:
   - a. Sound in air is about 1130 feet per second
   - b. Light or radio waves are about 300 x 10^6 meters per second
3. Symbol: Greek letter lambda
4. Unit: meters
5. Formula: Wavelength = velocity/frequency

E. Phase
Show Transparency fig. 88

1. Waves must be the same frequency to compare phase
2. In-phase - each wave occurs at the same time
3. Out-of-phase - each wave occurs at a different time
4. Phase angle - time between waves measured in electrical degrees

F. Frequency Spectrum
Show Transparency fig. 89

1. Power frequencies - zero Hz (DC), 50-60 Hz and 400 Hz
2. Audio frequencies - 20 Hz to 20 K Hz - frequencies that can be heard
3. Radio frequencies - above audio range - divided into bands used for different purposes
   - a. Very Low Frequency Band (VLF) - 3 K Hz to 30 K Hz, used for sonar
   - b. Low Frequency Band (LF) - 30 K Hz to 300 K Hz, seldom used
   - c. Medium Frequency Band (MF) - 300 K Hz to 3 M Hz, communications including AM broadcast
   - d. High Frequency Band (HF) - 3 M Hz to 30 M Hz, long range communications
   - e. Very High Frequency Band (VHF) - 30 M Hz to 300 M Hz, FM and TV, aircraft communications and radio navigation
   - f. Ultra High Frequency Band (UHF) - 300 M Hz to 3 G Hz, radio communications, some TV
   - g. Super High Frequency Band (SHF) - 3 G Hz to 30 G Hz, radar
   - h. Extremely High Frequency Band (EHF) - 30 G Hz to 300 G Hz, microwave

G. Decibels

1. Dimensionless units of power level
2. 3 db increase equals doubling of power level
3. 3 db represents a ratio of one power level to another on the order of 2 to 1

4. 12 db is twice as large as 9 db - relative measurement only because an actual value is not known for 9 db
5. Standard or reference - can vary - 0 db = 1 mW in 600 Ohms
6. Used to indicate gain or loss in a system - an amplifier could have a gain of 3 db

H. Oscilloscope

1. An instrument which allows the operator to look at AC signals and make voltage and time measurements

Show Transparency fig. 90

2. Operation:
   - a. Block diagram
   - b. Cathode Ray Tube (CRT)

Show Transparency fig. 91

   - c. Sweep-trace circuits
   - d. Vertical circuits
   - e. Trigger circuits
3. Controls
   - a. Power - controls on-off operation
   - b. Intensity - controls brightness of the display
   - c. Focus - Adjusts clarity of display
   - d. Scale illumination - adjusts illumination of grid
   - e. Magnifier - expands the sweep by a factor of 10
   - f. Horizontal sweep - (time/cm) - selects the time base sweep rate
   - g. Trigger control - selects trigger data
   - h. Position controls - positions the trace on the screen
   - i. Input control - vertical control (volts/cm) adjusts the amount of signal that will be the vertical position of the display
4. Measurements
   - a. Adjust required controls for a measurable display
   - b. Voltage measurement made on the vertical plane
   - c. The peak and peak-to-peak values are determined from the vertical display
   - d. The effective or RMS value is determined by multiplying the peak value of the AC signal by 0.637

f. The period of one cycle of the AC signal is determined from the horizontal portion of the display

g. The frequency is determined by calculation using $f = 1/t$

Show Transparency fig. 92

h. Phase measurements between two signals can be made by placing one signal on the vertical input and the other signal on the horizontal input. The resultant pattern is called a Lissajous figure.

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS. NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Alternating Current
2. Task Sheet - Oscilloscope
3. Experiment # 24 - The Oscilloscope
4. Experiment # 25 - Direct and Alternating Current
5. Check each student's work for completeness and accuracy
6. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

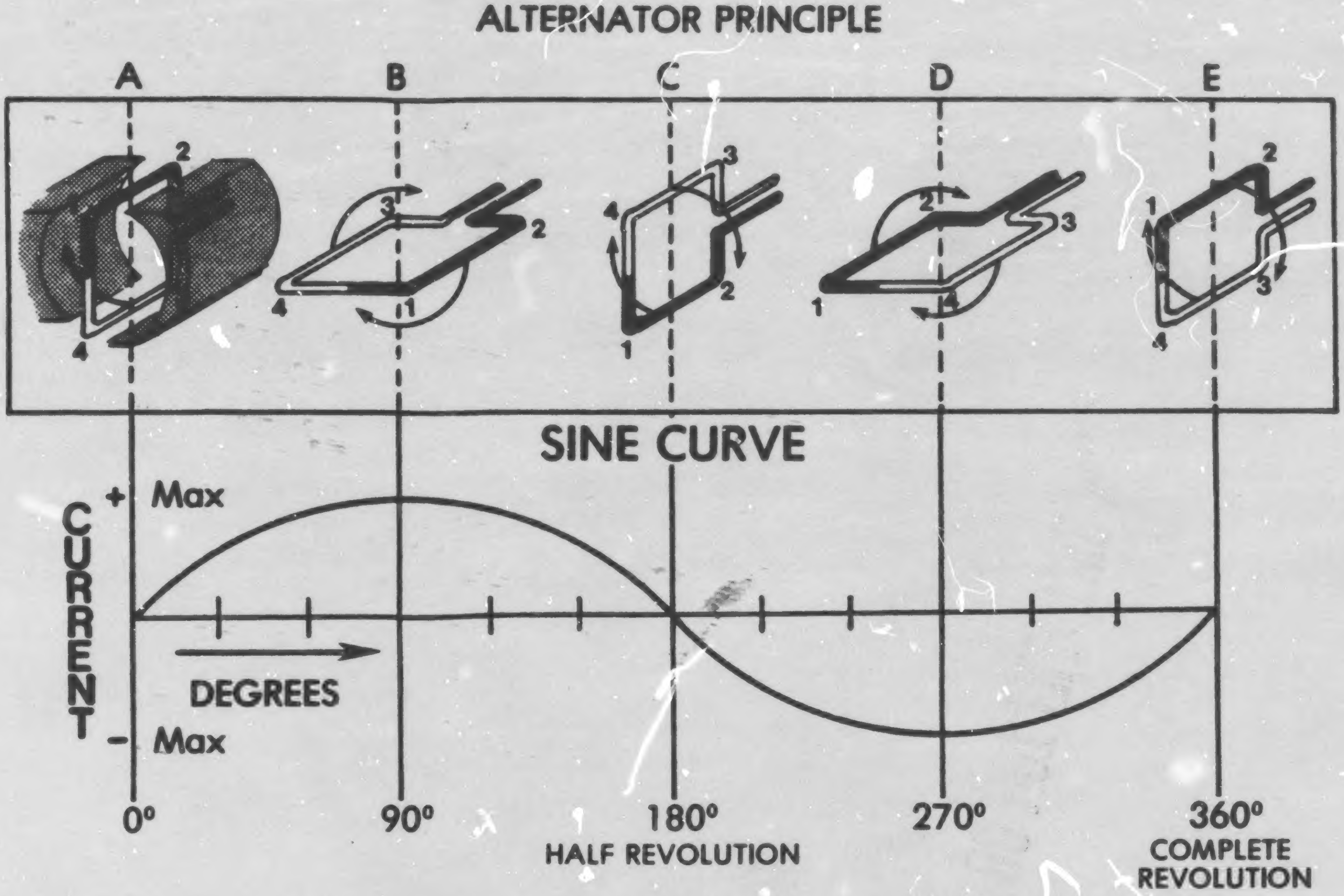
1. Ask oral questions
2. Test Sheet - Alternating Current
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Inductance

ALTERNATING CURRENT



ALTERNATOR PRINCIPLE

SINE CURVE

A
B
C
D
E
1
2
3
4
CURRENT
+ Max
- Max
DEGREES
0°
90°
180°
HALF REVOLUTION
270°
360°
COMPLETE REVOLUTION

ALTERNATOR WAVE FORM

19500

Fig. 86

SINE WAVE RELATIONSHIPS

From	To			
	Effective	Average	Peak	Peak-to-Peak
Effective(rms)		0.900	1.414	2.828
Average	1.110		1.571	3.142
Peak	0.707	0.637		2.000
Peak-to-Peak	0.354	0.318	0.500	

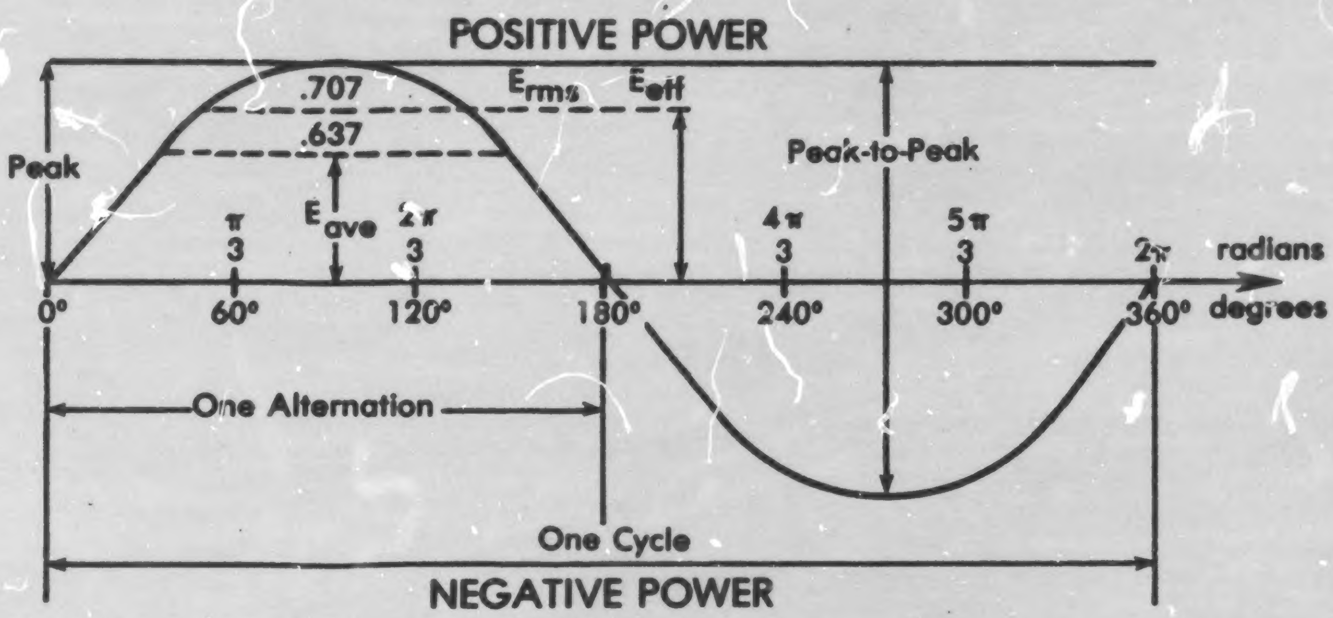
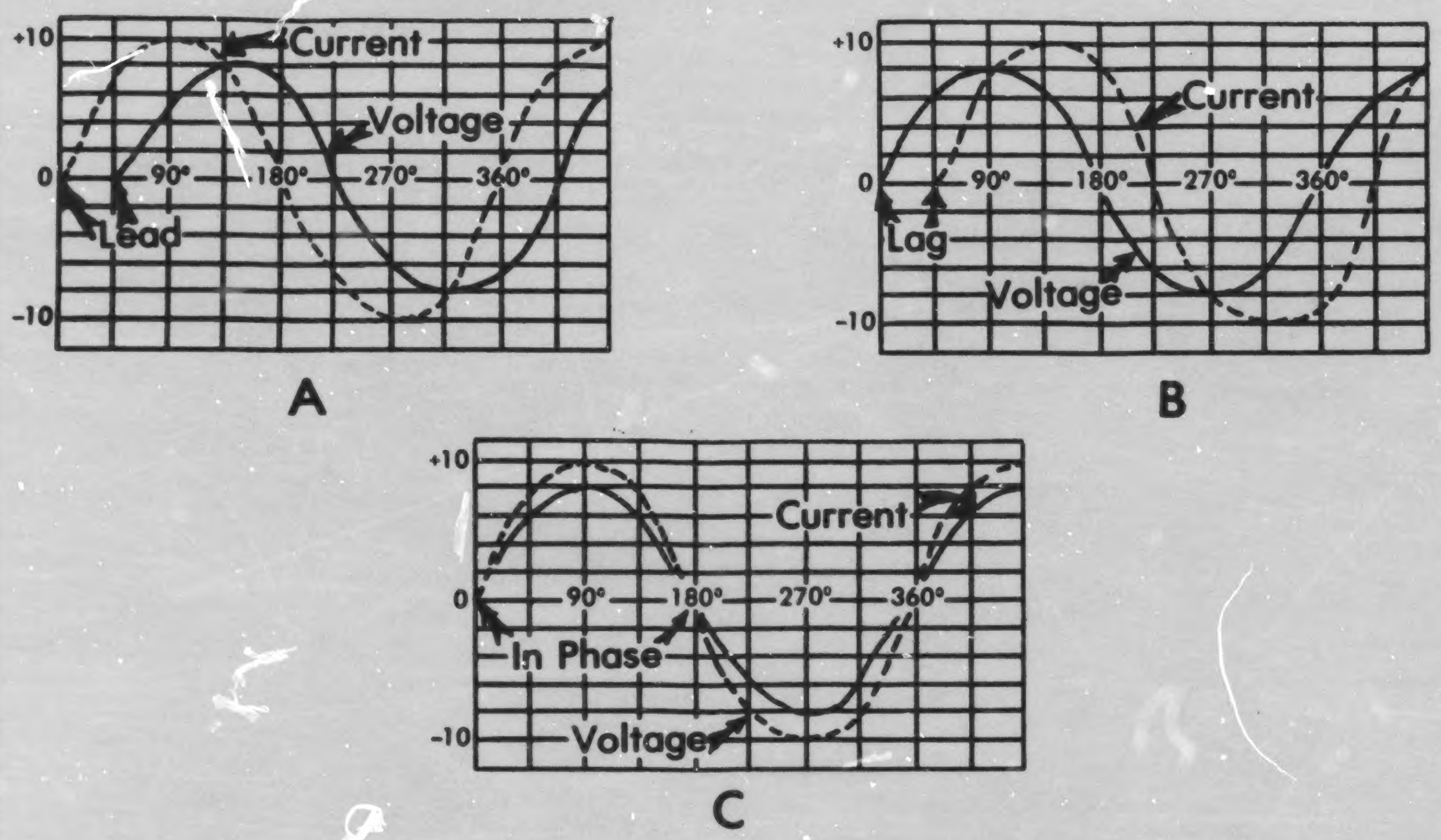

POSITIVE POWER
.707
E_{rms}
E_{eff}
.637
Peak
E_{ave}
Peak-to-Peak
$\frac{\pi}{3}$
$\frac{2\pi}{3}$
$\frac{4\pi}{3}$
$\frac{5\pi}{3}$
2π
radians
0°
60°
120°
180°
240°
300°
360°
degrees
One Alternation
One Cycle
NEGATIVE POWER

Fig. 87

ALTERNATING CURRENT



VOLTAGE AND CURRENT MIGHT EITHER LEAD OR LAG EACH OTHER DEPENDING ON CIRCUIT CONDITION. THEY ARE SAID TO BE IN PHASE WHEN GIVEN VALUES ARE REACHED AT THE SAME TIME.

Fig. 88

THE FREQUENCY SPECTRUM

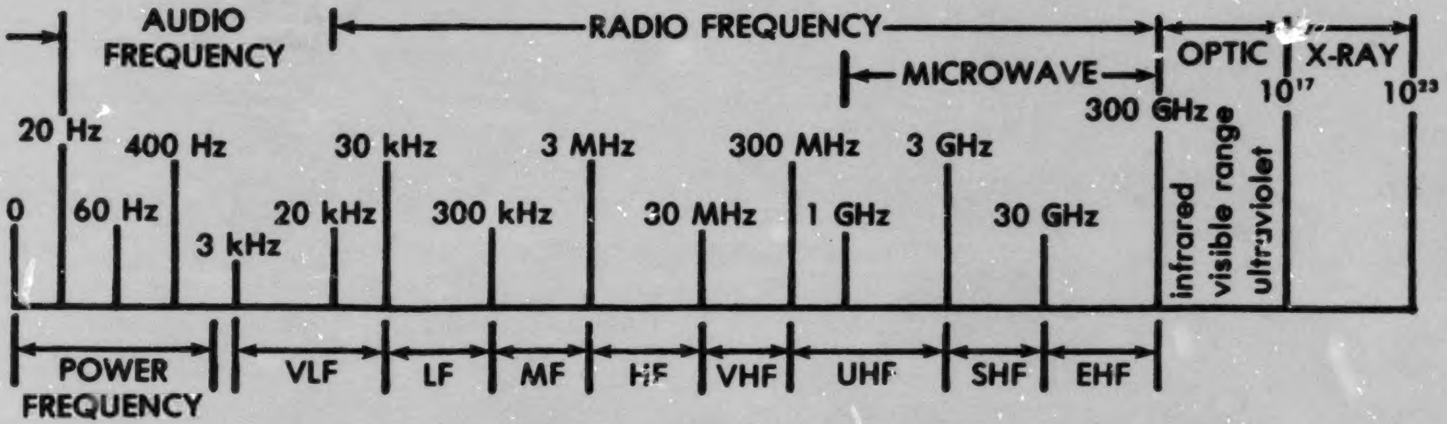
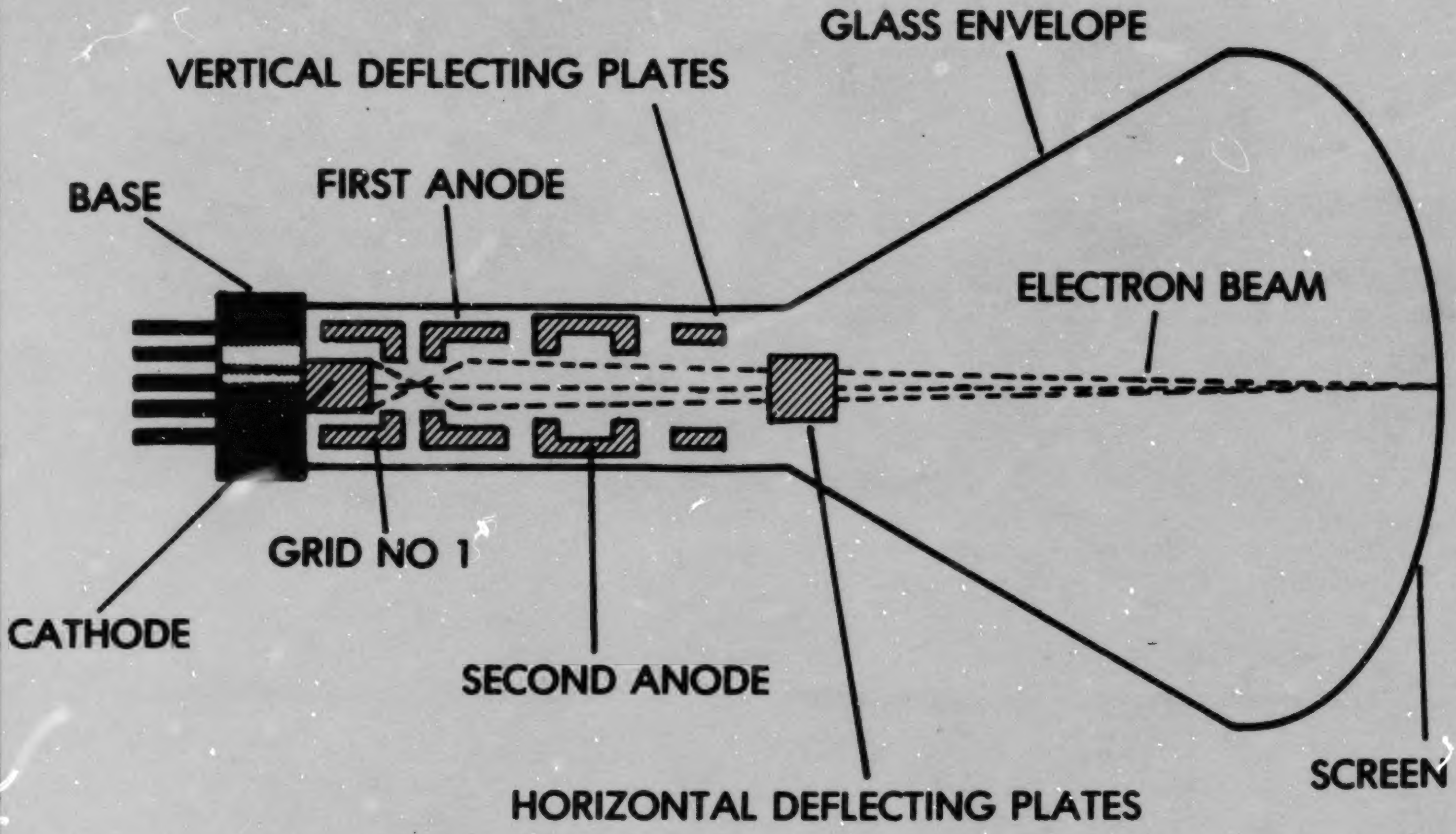

AUDIO FREQUENCY
RADIO FREQUENCY
MICROWAVE
OPTIC
X-RAY
0
20 Hz
60 Hz
400 Hz
3 kHz
20 kHz
30 kHz
300 kHz
3 MHz
30 MHz
300 MHz
1 GHz
3 GHz
30 GHz
300 GHz
infrared
visible range
ultraviolet
10^{17}
10^{23}
POWER FREQUENCY
VLF
LF
MF
HF
VHF
UHF
SHF
EHF

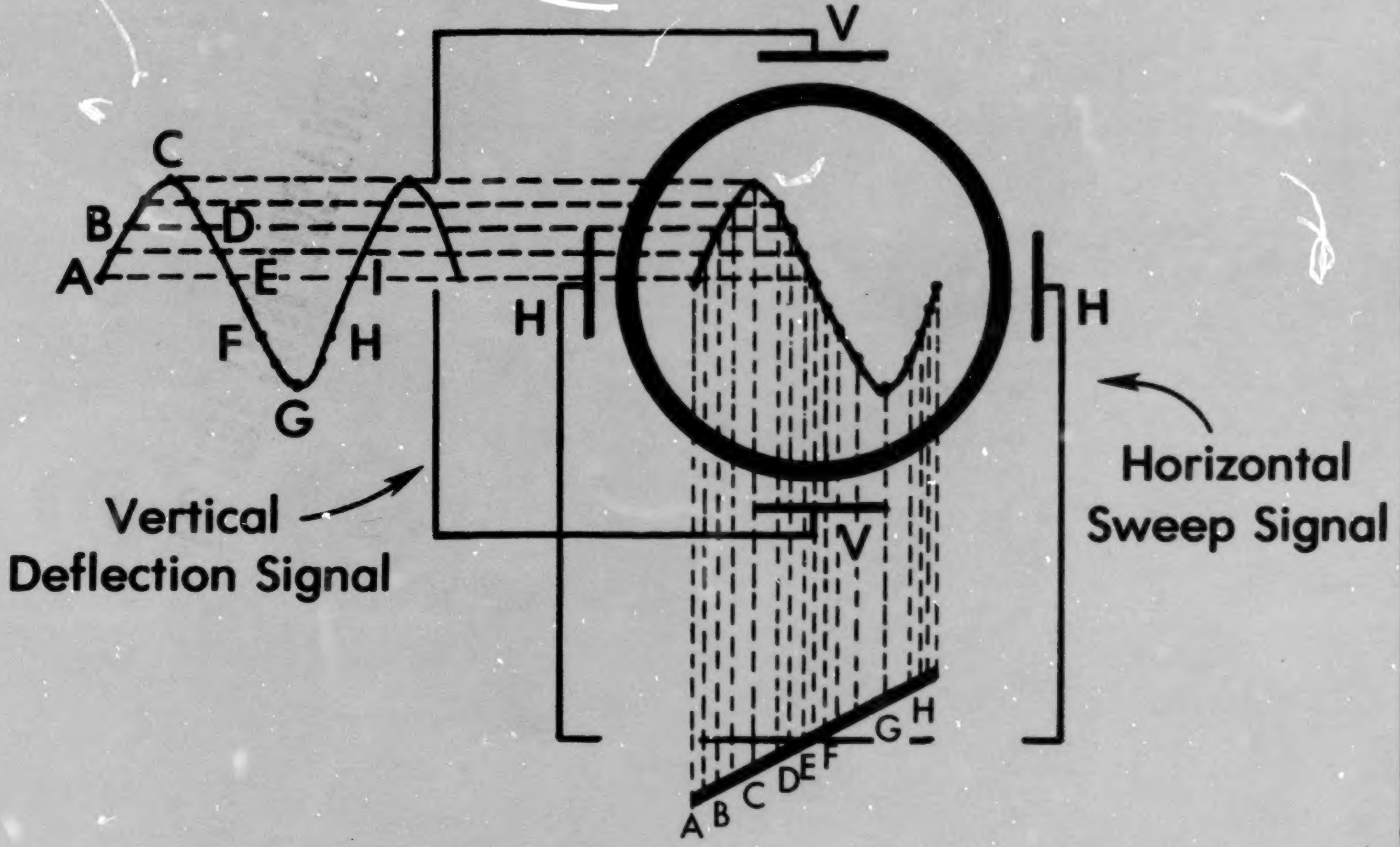
Fig. 89

CATHODE RAY TUBE

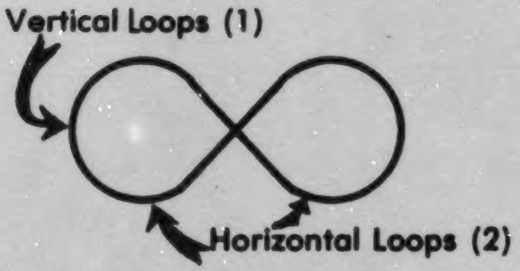
(with electrostatic deflection/focusing)


GLASS ENVELOPE
VERTICAL DEFLECTING PLATES
BASE
FIRST ANODE
ELECTRON BEAM
GRID NO 1
CATHODE
SECOND ANODE
SCREEN
HORIZONTAL DEFLECTING PLATES

CATHODE RAY TUBE


V
C
B
D
A
E
I
F
H
G
H
H
V
Vertical Deflection Signal
Horizontal Sweep Signal
A B C D E F G H

LISSAJOUS PATTERNS-FREQUENCY



THE RATIO OF HORIZONTAL TO VERTICAL CLOSED LOOPS IS EQUAL TO THE RATIO OF VERTICAL TO HORIZONTAL FREQUENCY

$$\frac{L_H}{L_V} = \frac{F_V}{F_H}$$

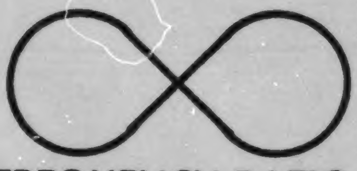
WHERE:

F_V = Vertical Frequency

F_H = Horizontal Frequency

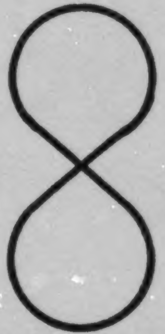
L_V = Vertical Loops

L_H = Horizontal Loops



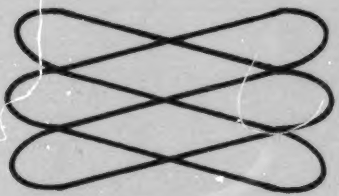
FREQUENCY RATIO

$$\frac{F_V}{F_H} = \frac{L_H}{L_V} = \frac{2}{1}$$



FREQUENCY RATIO

$$\frac{F_V}{F_H} = \frac{L_H}{L_V} = \frac{1}{2}$$



FREQUENCY RATIO

$$\frac{F_V}{F_H} = \frac{L_H}{L_V} = \frac{2}{3}$$

In a direct current circuit, the current always flows from the negative terminal of the source, through the load, and back to the positive terminal. This is the distinguishing characteristic of DC; DC is unidirectional with respect to emf and current.

As we have seen in previous introductory discussions, alternating current is characterized by periodic reversals of emf and current. At any given instant, current flow still follows the - to + rule, but as the emf reverses its polarity, so does the current.

The maximum or peak value of an AC voltage or current is the highest value attained during a single cycle, on either a positive or negative alternation. The instantaneous value of voltage or current is the magnitude of the quantity at any given instant. If you are asked to state the instantaneous value of some voltage wave, you must also be told the phase at which this instantaneous voltage is to be read. The average value of a single alternation is 0.637 times the peak value. You should commit to memory the fact that the average voltage or current of a single alternation of sinusoidal (sine wave shape) AC may be found by multiplying the peak value by 0.637 as shown in figure 1.

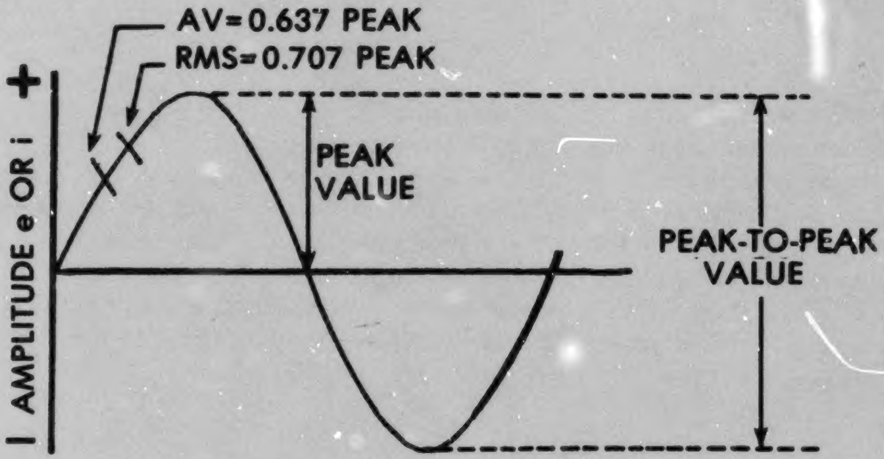


Figure 1

The effective value of voltage or current in AC has an entirely different meaning than the average just discussed. To understand the significance of the effective value of a voltage or current, consider this example: a direct current of 1 Amp; that is, a steady flow of 1 Amp causes a certain conductor to heat to a certain temperature in a fixed period of time. An alternating current of 1 Amp peak value, however, causes only 70.7 per cent as much heat as the direct current of 1 Amp. We say, therefore, that a peak current of any magnitude is only 0.707 times as effective in producing heat as a steady current of the same magnitude. The inability of the AC to produce the same heating effect as DC of the same magnitude as the peak AC is due to the fact that the AC reaches this magnitude for only a relatively short time in each cycle. All the rest of the time, the magnitude is less than peak. On the other hand, DC of a given magnitude is "always up there", so to speak, maintaining the same high value throughout the duty period. Thus, the effective value of any AC current or voltage = 0.707 times the peak value as shown in figure 1.

The maximum value or amplitude of an alternating voltage or current is also called the peak value. The peak value of voltage of an AC wave is the highest voltage that is reached on either the positive or negative alternation. The period of the wave is the time required to complete 1 cycle of the wave, and the wavelength is the distance traveled by the wave in one cycle.

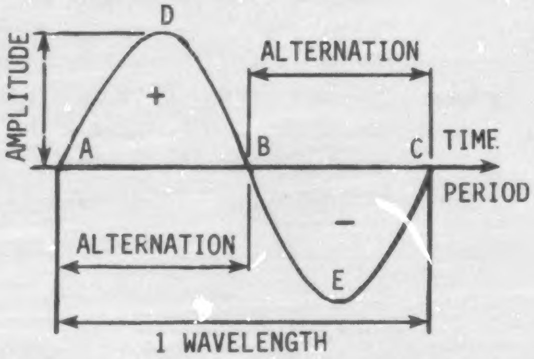


Figure 2

The sine wave with its time axis divided in degrees is shown below in figure 3. The term phase, as referred to any wave, relates to the position of a point on the wave in terms of the markings on the horizontal axis. For example, point A, located on the curve itself, is said to be in the 45° phase because a vertical line dropped through A passes through the 45° marking on the time axis; by the same reasoning, point B on the curve is in the 90° phase. Two waves superimposed on the same axis are said to be in-phase when they attain corresponding amplitudes at the same phases. Thus, the waves in figure 3 are in-phase with each other. When corresponding amplitudes occur at different phases, the waves are then out-of-phase.

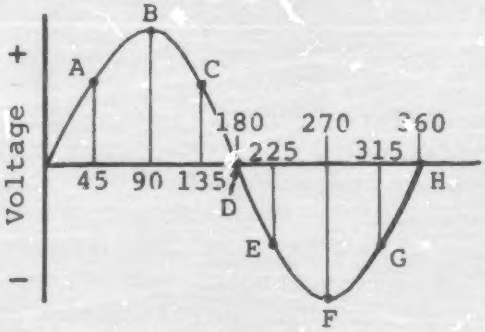


Figure 3

ALTERNATING CURRENT

VI-A-1(AS)
Key

Name ____________________ Date ____________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

Average 1. The _____ value of a single alternation of a sine wave is 0.637 times the peak value.

63.7 V 2. If the peak value of a sine wave is 100 V, the average value is _____.

6.37 V 3. If the peak value of a sine wave current is 10 A, the average value is ___.

127.4 V 4. If the peak value of a sine wave voltage is 200 V, the average value of one alternation is ____.

Zero 5. The average value of a complete sine wave cycle is _____.

7.07 V 6. An AC with a peak value of 10 V causes the same heating effect as a DC of ______.

7.07 mA 7. An AC with a peak value of 100 mA causes the same heating effect as a DC of _____.

10.6 V 8. An AC with a Peak-to-Peak value of 30 V will have an RMS value of _____.

Audio 9. Alternating currents between about 20 Hz and 20,000 Hz when changed into sound by a speaker are called ____ frequencies.

Radio 10. Alternating currents of frequencies higher than 20 K Hz are called _____ frequencies.

833 u Second 11. The period of an AC wave having a frequency of 1.20 K Hz is _____.

f = 1 / t 12. The formula for the frequency of an AC wave is _____.

180 13. An alternation of sine wave AC is ____ electrical degrees.

360 14. A cycle of AC is _____ electrical degrees.

RMS
Effective ________ 15. The ____ value of AC will produce the same heat in a resistor as an equal value of DC.

Frequency ________ 16. The number of cycles per second is called the ____ of the wave.

Period ________ 17. The amount of time for one cycle is called the ____ of the wave.

20.0 Meters ________ 18. The wavelength of a sine wave having a frequency of 15 M Hertz is _____.

Phase ________ 19. The angular difference between two sine waves of the same frequency is called the ____.

Focus ________ 20. The _____ adjusts the clarity of the display on an oscilloscope.

Horizontal ________ 21. The _____ control is used to control the time base sweep rate on the oscilloscope.

Vertical ________ 22. The _____ control is used to control the amplitude portion of the oscilloscope display.

CRT ________ 23. The _____ provides the visual display of the waveforms on an oscilloscope.

2 or 3 ________ 24. For the clearest presentation on an oscilloscope, _____ cycles of input wave should be displayed.

Lissajous ________ 25. A/an ____ display on an oscilloscope can be used to determine the phase relationship between two waves.

OSCILLOSCOPE

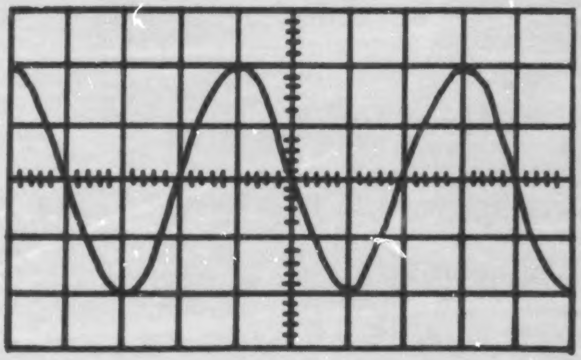
VI-A-1(TS)
Key

Name ______________________ Date ______________________

Directions: Using the oscilloscope display and the settings indicated for each set of questions, determine the values for each wave. Place your answers in the space provided. If you have any questions, ask your instructor.

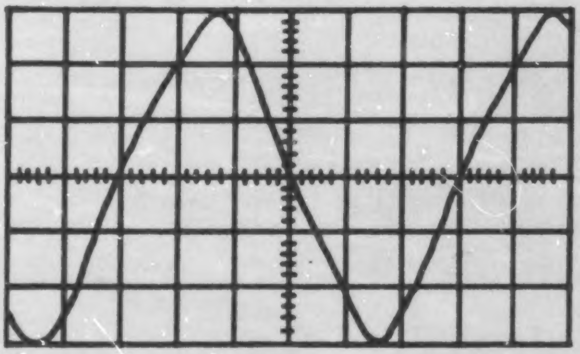
VERTICAL at .1 Volt/cm
HORIZONTAL at 5 m Sec/cm

1. Peak Voltage .2 V
2. Pk-Pk Voltage .4 V
3. RMS Voltage .1414 V
4. Period .02 Sec
5. Frequency 50 Hz



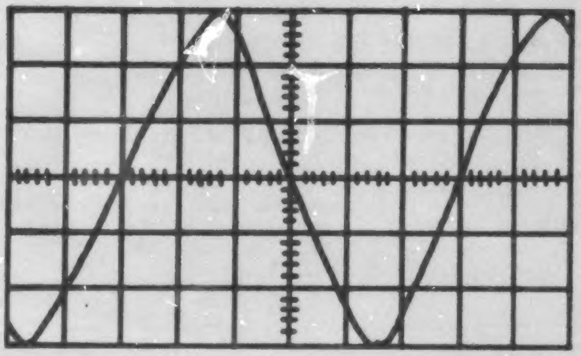
VERTICAL at .5 Volt/cm
HORIZONTAL at 10 m Sec/cm

6. Peak Voltage 1.5 V
7. Pk-Pk Voltage 3 V
8. RMS Voltage 1.06 V
9. Period .06 Sec
10. Frequency 16.7 Hz



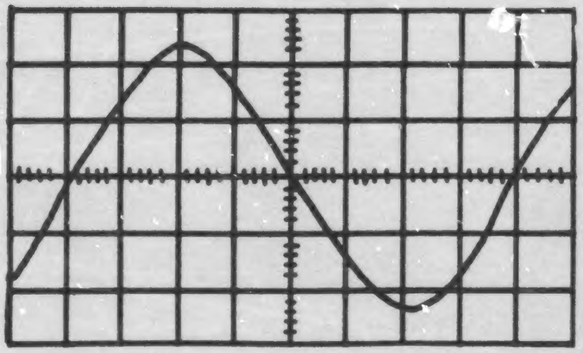
VERTICAL at .02 Volt/cm
HORIZONTAL at 2 Sec/cm

11. Peak Voltage 60 mV
12. Pk-Pk Voltage 120 mV
13. RMS Voltage 42.4 mV
14. Period 12 μSec
15. Frequency 83.3 K Hz



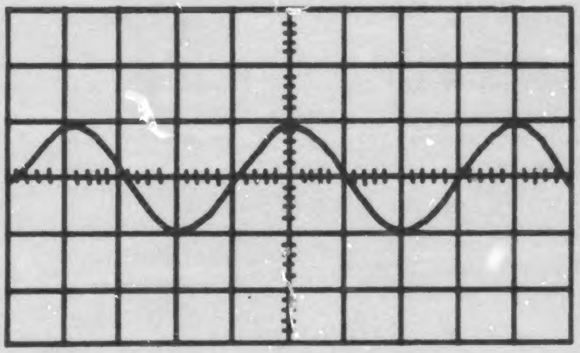
VI-A-1(TS)
Key

VERTICAL at .2 Volt/cm
HORIZONTAL at .1 Sec/cm



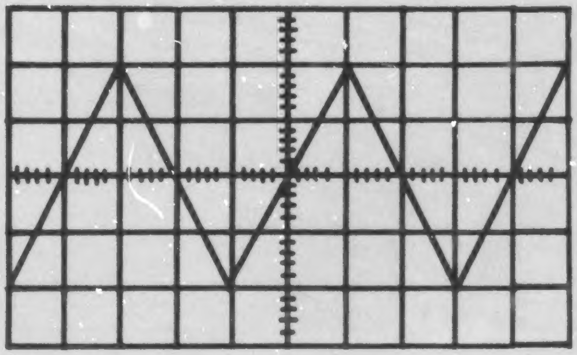
16. Peak Voltage .48 V
17. Pk-Pk Voltage .96 V
18. RMS Voltage .339 V
19. Period .8 Sec
20. Frequency 1.25 Hz

VERTICAL at 1 m Volt/cm
HORIZONTAL at 10 Sec/cm



21. Peak Voltage 1 mV
22. Pk-Pk Voltage 2 mV
23. RMS Voltage .707 mV
24. Period 38 μ Sec
25. Frequency 26.3 K Hz

VERTICAL at 50 m Volts/cm
HORIZONTAL at 1 m Sec/cm



26. Peak Voltage 100 mV
27. Pk-Pk Voltage 200 mV
28. RMS Voltage
29. Period 4 m Sec
30. Frequency 250 Hz

Directions: With your lab partner, set up an oscilloscope and signal generator. Take turns setting the generator at various levels and frequencies and operating the scope. If you have any problems or questions, ask your instructor.

INSTRUCTOR CHECK ________

TEST

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

D 1. A sine wave having a peak value of 25.5 V will have a peak-to-peak value of ____.
A. 12.75 V B. 25.5 V C. 38.25 V D. 51.0 V

B 2. A sine wave having a peak value of 50 V will have an RMS value of ____.
A. 50 V B. 35.4 V C. 31.8 V D. 25 V

A 3. A sine wave having a peak value of 80.5 V will have an effective value of ____.
A. 56.9 V B. 161 V C. 80.5 V D. 51.3 V

B 4. A sine wave having a period of 1/1000 second will have a frequency of ____.
A. 2,000 Hz B. 1,000 Hz C. 500 Hz D. 250 Hz

C 5. A sine wave taking 5 u seconds for a complete cycle will have a frequency of ____.
A. 5 K Hz B. 200 Hz C. 200 K Hz D. 250 K Hz

B 6. If the frequency of a sine wave is 550 Hz, the period of the wave is ____.
A. 1 m Sec B. 1.8 m Sec C. 2 m Sec D. 2.8 m Sec

C 7. The DC voltage necessary to produce the same amount of power as a 10 V peak sine wave is ____.
A. 20 V B. 10 V C. 7.07 V D. 6.37 V

B 8. In one cycle of alternating current there is/are ____ alternations.
A. one B. two C. three D. four

D 9. A term that can be used to identify the effective value of an AC is ____.
A. peak B. peak-to-peak C. average D. RMS

B 10. The value which represents the difference between the maximum positive and maximum negative values of an AC sine wave is called the ____ value.
A. peak B. peak-to-peak C. average D. RMS

C_____ 11. The wavelength of an electromagnetic wave is determined by its _____.
A. velocity and frequency
C. frequency and time
B. velocity per second
D. magnitude

D_____ 12. The formula for finding the wavelength of an AC wave is wavelength = _____.
A. V/t B. Vt C. f/V D. V/f

C_____ 13. Electromagnetic waves travel at approximately _____.
A. 186,000 meters per second
B. 186,000 miles per hour
C. 300,000,000 meters per second
D. 300,000,000 meters per hour

A_____ 14. For most general purpose work the oscilloscope shows how _____ changes with changes in time.
A. voltage B. current C. frequency D. period

B_____ 15. Except for special purpose oscilloscopes, the displayed waveform must be a _____ wave.
A. sine B. cyclical C. square D. graph

C_____ 16. The electron beam in a CRT is moved by electrostatic forces applied to the beam by the ____.
A. grids B. cathode C. deflection plates

A_____ 17. For most applications, the horizontal deflection amplifier is used to amplify the _____ signal.
A. sweep B. input C. trigger D. blanking

D_____ 18. The calibrated vertical section of an oscilloscope lets you make _____ measurements.
A. time B. period C. frequency D. voltage

A_____ 19. A calibrated horizontal section of an oscilloscope allows accurate _____ measurements.
A. time B. current C. frequency D. voltage

C_____ 20. The trace-retrace of the electron beam is controlled by a ____ wave in most oscilloscopes.
A. square B. sine C. sawtooth D. distorted

Directions: Match the items in the left column with the items in the right column. Place the letter representing the correct match in the space provided. Be sure to check your answers.

E	21. Intensity control	A. Input wave
D	22. Horizontal control	B. Volts/cm
B	23. Vertical control	C. Clarity of display
C	24. Focus control	D. Time/cm
F	25. Sawtooth wave	E. Brightness of display
		F. Sweep wave

VI-B-1(I)

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

SUBJECT: Inductance

AIM: Upon successful completion of the lesson, the student will be able to demonstrate understanding of inductance, transformers and inductive reactance by answering questions, constructing circuits, making calculations, and analyzing circuits.

TEACHING AIDS: Chalkboard, overhead projector, Transparencies 19500, figs. 93-100

MATERIALS:
Assignment Sheet - Inductance
Experiment # 28 - Inductance
Experiment # 29 - Transformers
Experiment # 30 - Inductive Reactance
Test Sheet - Inductance

TOOLS AND EQUIPMENT: Student lab station, component set, oscilloscope

REFERENCES:
DeVito, Introduction to Electricity and Electronics
Fowler, Electricity - Principles and Applications
Grob, Basic Electronics

PREREQUISITE EXPERIENCE OF THE LEARNER: All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Many electrical and electronic devices operate on the principle of inductance. Therefore, it is important for you to develop an understanding of inductances and their application. In this lesson you will learn to identify various types of inductors and learn to work with series and parallel inductances. You will learn the relationships between inductance, frequency and reactance. Among the uses of inductance, you will learn how transformers are used in electronics. You will understand how they work and the terminology associated with them.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Inductance	1. Characteristics a. The property of a circuit that opposes any change in current b. The ability of a conductor to produce induced voltage in itself when the current

varies

Show Transparency fig. 93

c. Coils have more inductance due to the concentration of flux
d. Induced voltage is the result of flux cutting across a conductor

Show Transparency fig. 94

e. Induction is by a varying current and not the amount of current
f. Symbol: L
g. Unit: Henry
h. Formula: $L = E_L / (\Delta I / \Delta t)$

2. Physical characteristics of solenoid
   a. Number of turns (n) - increase to increase inductance
   b. Area of each turn (A) - size of each coil loop
   c. Permeability of core (μ) - core materials ability to concentration flux
   d. Length of coil (l) - from end to end
   e. Formula: $L = (\mu n^2 A) / l$

Show Transparency fig. 95

3. Lenz's Law
   a. Any voltage generated by induction must oppose the motion producing the induced voltage
   b. E_L reverses polarity with reversal of current flow
   c. E_L reverses polarity as current changes between increasing or decreasing values

B. Mutual Inductance

Show Transparency fig. 96

1. Characteristics
   a. When current in an inductor changes, the flux can cut across any nearby inductor producing induced voltage
   b. Symbol: L_M
   c. Unit: Henry
   d. Iron core increases the mutual inductance
   e. Flux leakage is flux which does not cut the other conductor

Show Transparency fig. 97

2. Coefficient of coupling
   a. The fraction of flux from one coil cutting across another
   b. Symbol: k
   c. Coefficient of coupling has no units
   d. k is increased by placing coils close together
   e. Unity coupling: when k = 1 caused by all the flux from one cutting the other

- f. Two coils on a common iron core have unity coupling
- g. Tight coupling = high value of k
- h. Loose coupling = low value of k
- i. No coupling: ($k = 0$) no mutual inductance

3. Mutual inductance calculations
   - a. Mutual inductance increases with higher values of k
   - b. Formula: $L_M = k \sqrt{L_1 \times L_2}$
   - c. L_1 and L_2 are self inductance values of the coils
4. Variable inductance
   - a. Tapped coil
   - b. Slider contact
   - c. Adjustable slug or core
   - d. Variometer (varies relative position)

Show Transparency fig. 98

5. Series-Parallel inductance
   - a. Series No L_M : $L_T = L_1 + L_2 \ldots$
   - b. Parallel No L_M : $L_T = 1 / (1/L_1 + 1/L_2 \ldots$
   - c. Series Aiding: $L_T = L_1 + L_2 + 2L_M$
   - d. Series Opposing: $L_T = L_1 + L_2 - 2L_M$
6. Stray inductance
   - a. All coils and conductors have inductance
   - b. Stray inductance is the inductance of any wiring not intended to be in the circuit

C. Transformers

Show Transparency fig. 99

1. Characteristics
   - a. Common application of mutual inductance
   - b. Purpose is to transfer power from primary to secondary
   - c. Can transform (step-up or step-down) voltage
2. Transformer ratios
   - a. Turns ratio = T_p / T_s or n_p / n_s
   - b. Voltage ratio = E_p / E_s
   - c. Current ratio = I_s / I_p
   - d. $T_p / T_s = E_p / E_s = I_s / I_p$
3. Secondary current and power
   - a. Ohm's Law applies: $I_s = E_s / R_L$
   - b. Secondary power: $P_s = I_s^2 \times R_L$

c. Total secondary power equals total primary power with 100% efficiency and unity coupling

4. Auto-transformers
   a. Acts as tapped coil
   b. Has step-up or step-down ratio
   c. No electrical isolation between primary and secondary
5. Transformer efficiency
   a. Ratio of power out to power in
   b. Most losses due to resistance in windings
   c. Power transformers have efficiencies of 80 to 95%
   d. Formula: Efficiency % = $(P_{out}/P_{in}) \times 100$
6. Core losses
   a. Eddy currents
      (1) AC induced into the core itself
      (2) Uses power
      (3) Greater at higher frequencies
   b. Hysteresis losses
      (1) With AC, magnetic domain reverse directions
      (2) Energy is required
7. Core types
   a. Laminated
      (1) Each section insulated from each other
      (2) Helps reduce Eddy currents
      (3) Used at power frequencies
   b. Powdered iron
      (1) Individual insulated granules pressed into a solid form
      (2) Helps reduce Eddy currents at higher frequencies
   c. Ferrite
      (1) Ceramic material
      (2) Insulator (reduces current)
      (3) Used at higher frequencies
   d. RF shielding
      (1) Metal cover of copper or aluminum
      (2) Eddy currents are induced in the shield
      (3) Helps prevent stray inductance

D. Inductive Reactance

Show Transparency fig. 100

1. Characteristics
   a. Caused by the self induced voltage
   b. Symbol: X_L
   c. Units: Ohms

   d. X_L can reduce current flow in AC circuit
   e. No X_L in DC circuit
   f. The higher the frequency, the greater the X_L
   g. Formula: $X_L = 2 \pi f L$
   h. Formula good for sine wave only
2. Series and parallel X_L
   a. Series: $X_{LT} = X_{L1} + X_{L2} \ldots$
   b. Parallel: $X_{LT} = 1/(1/X_{L1} + 1/X_{L2}) \ldots$
3. Ohm's Law
   a. Formula: $X_L = E_L / I_L$
   b. If voltage is RMS, then current is also RMS
   c. Must use values which apply
4. Phase relationship
   a. Voltage leads current by 90^o
   b. ELI
5. Impedance
   a. Total opposition to current by R and X_L in Ohms
   b. Formula: $Z^2 = R^2 + X_L 2$
   c. Use vector diagram to solve
6. Coil Q
   a. Ratio of X_L to R
   b. Quality measure of a coil
   c. $Q = X_L / R$

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Inductance
2. Experiment # 28 - Inductance
3. Experiment # 29 - Transformers
4. Experiment # 30 - Inductive Reactance
5. Check each student's work for completeness and accuracy
6. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions

2. Test Sheet - Inductance
3. 70% correct is required for satisfactory completion of the lesson

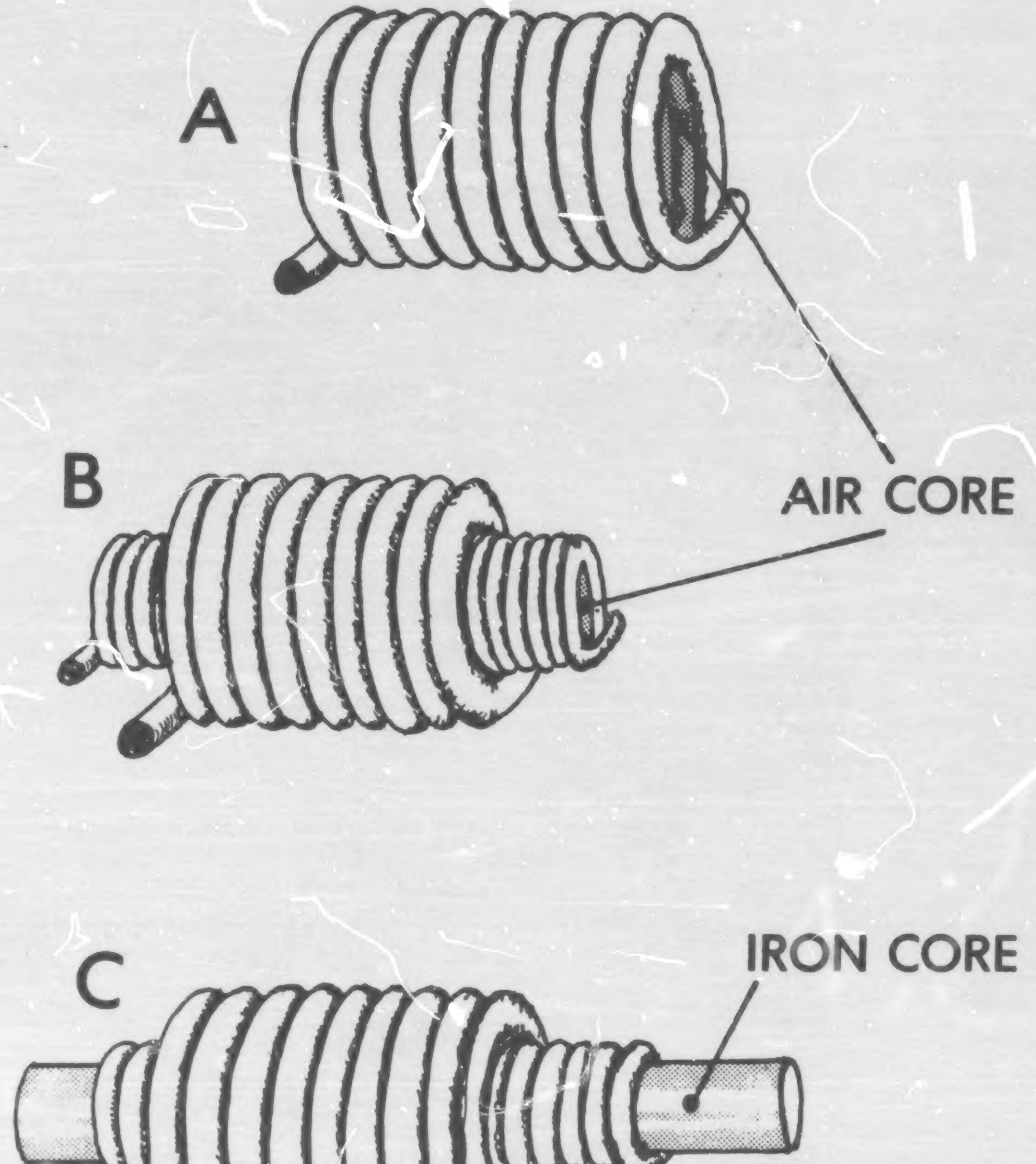
---

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

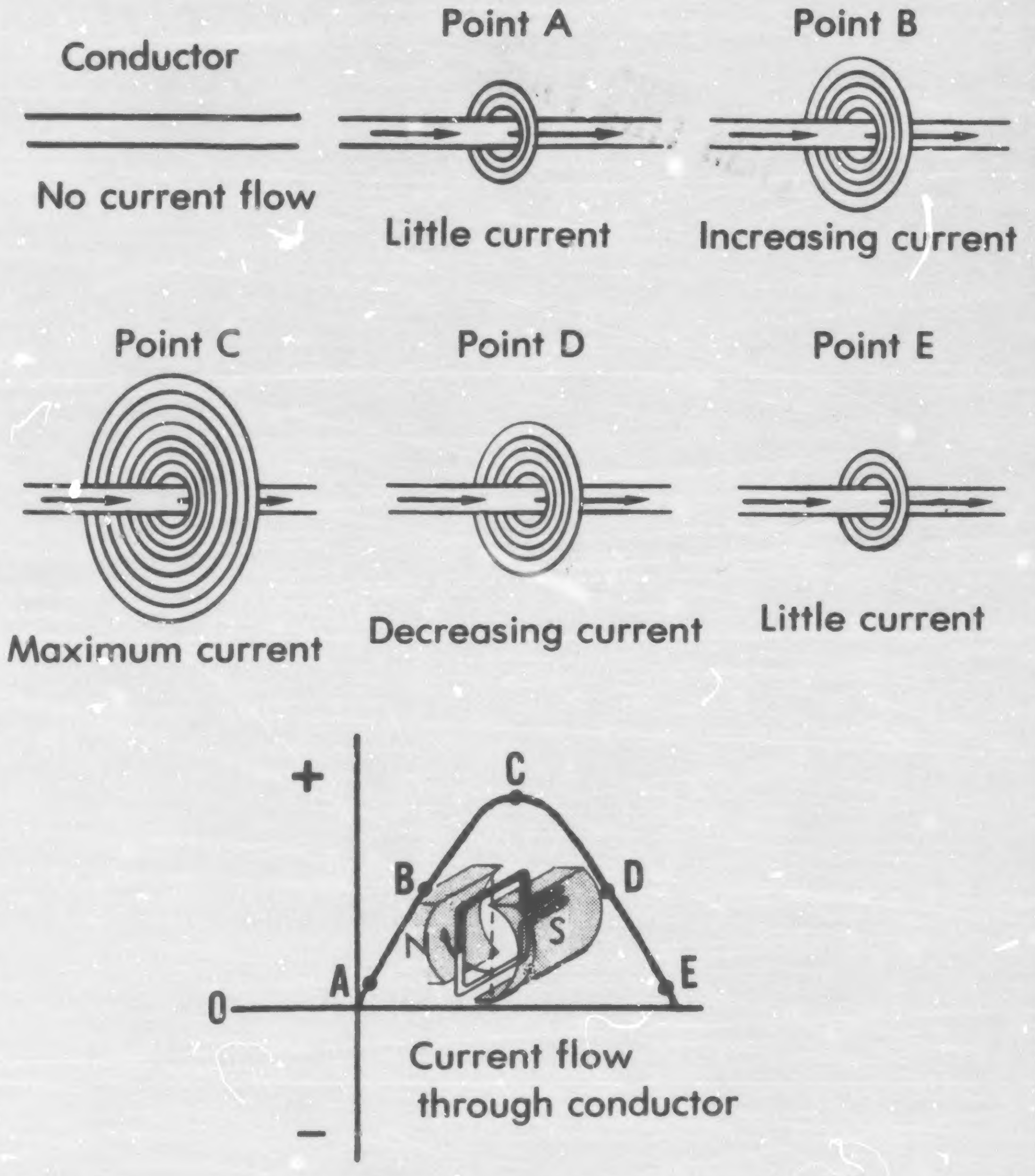
1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: Capacitance

COILS OF VARIOUS INDUCTANCES

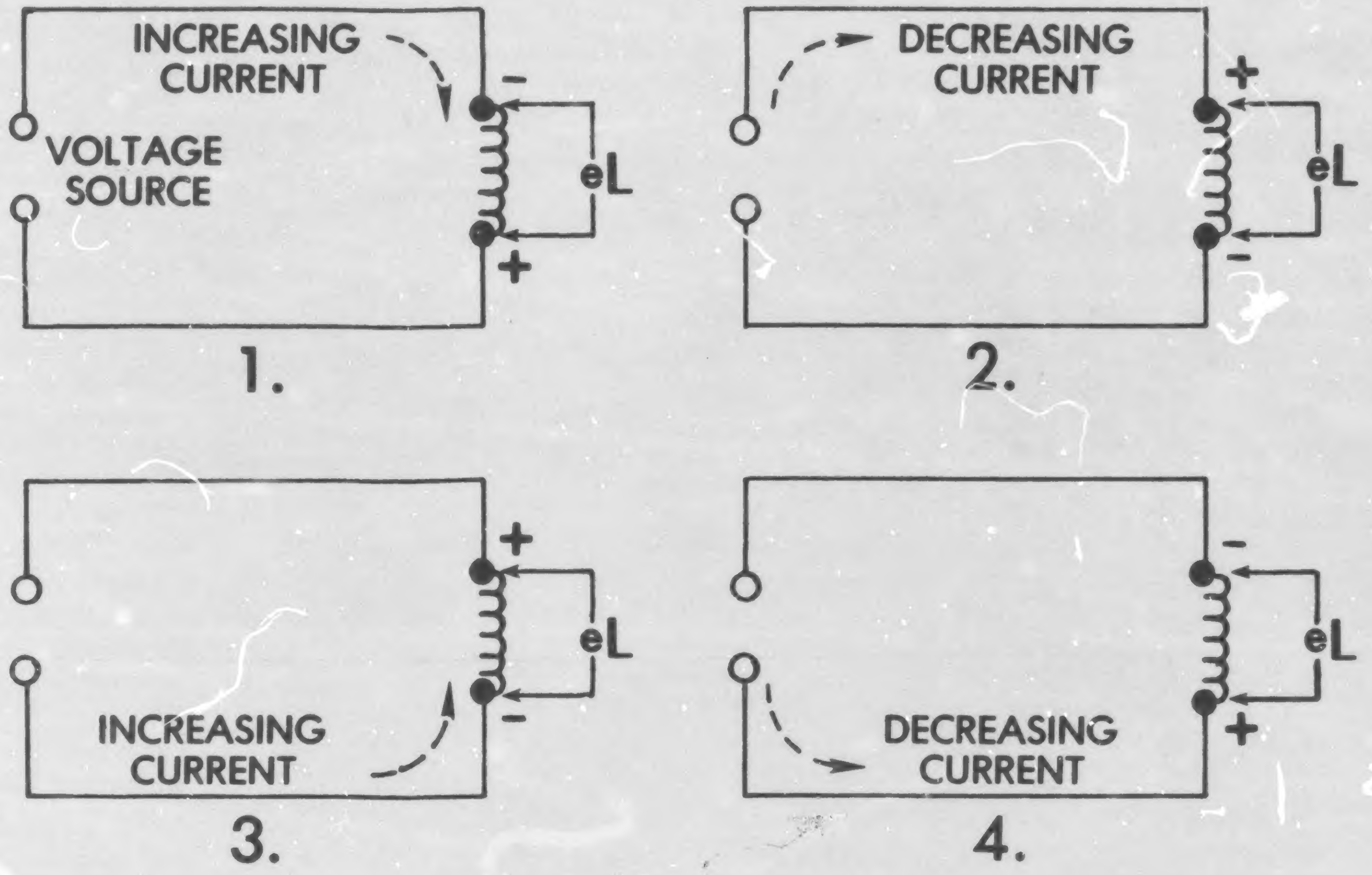

A
B
AIR CORE
C
IRON CORE

INDUCTION


Conductor
No current flow
Point A
Little current
Point B
Increasing current
Point C
Maximum current
Point D
Decreasing current
Point E
Little current
+
C
B
D
N
S
A
E
0
Current flow
through conductor
–

RELATIONSHIP BETWEEN CURRENT THROUGH A CONDUCTOR AND ITS MAGNETIC FIELD.

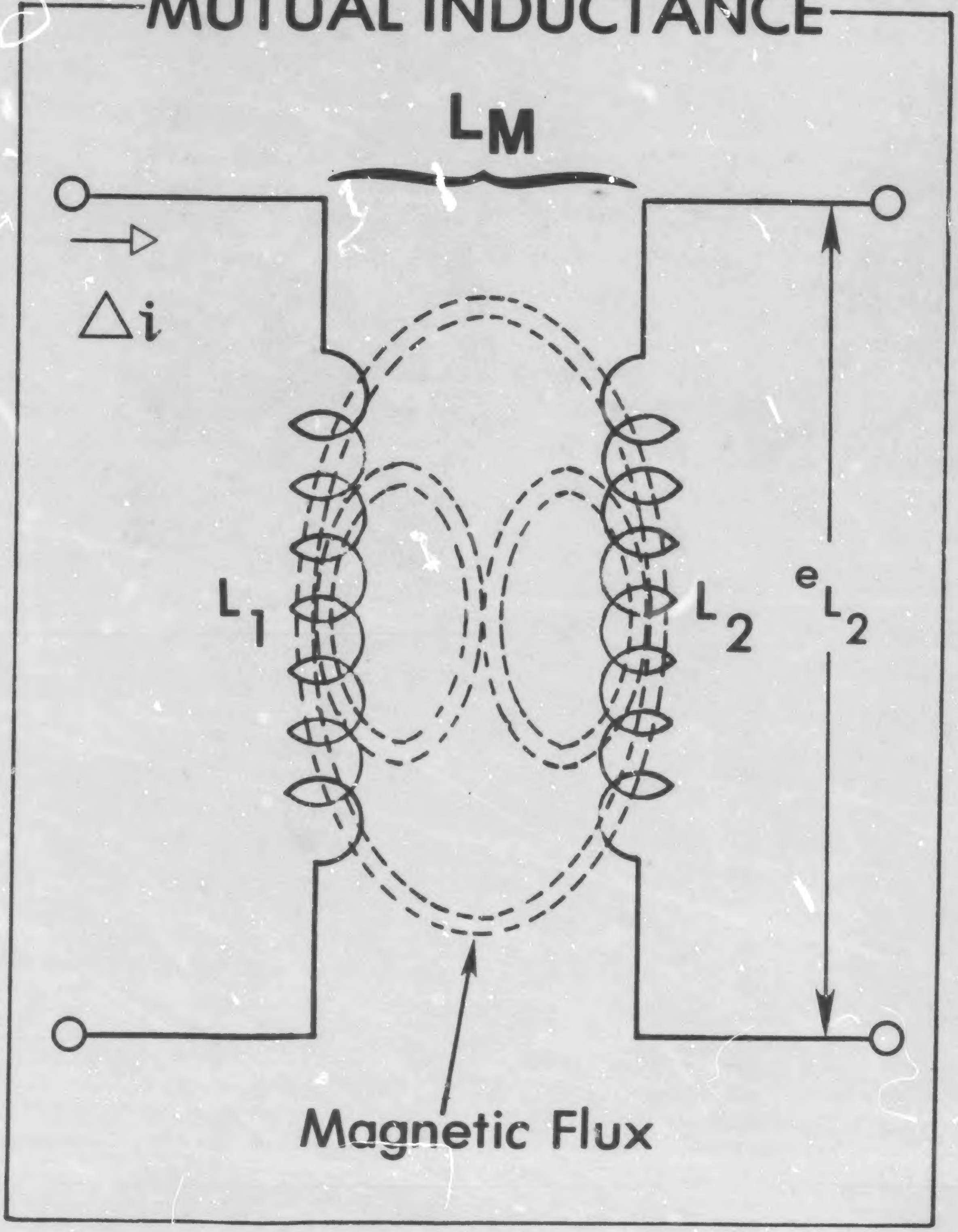
LENZ'S LAW


INCREASING CURRENT
VOLTAGE SOURCE
−
+
eL
1.
DECREASING CURRENT
+
−
eL
2.
+
−
eL
INCREASING CURRENT
3.
−
+
eL
DECREASING CURRENT
4.

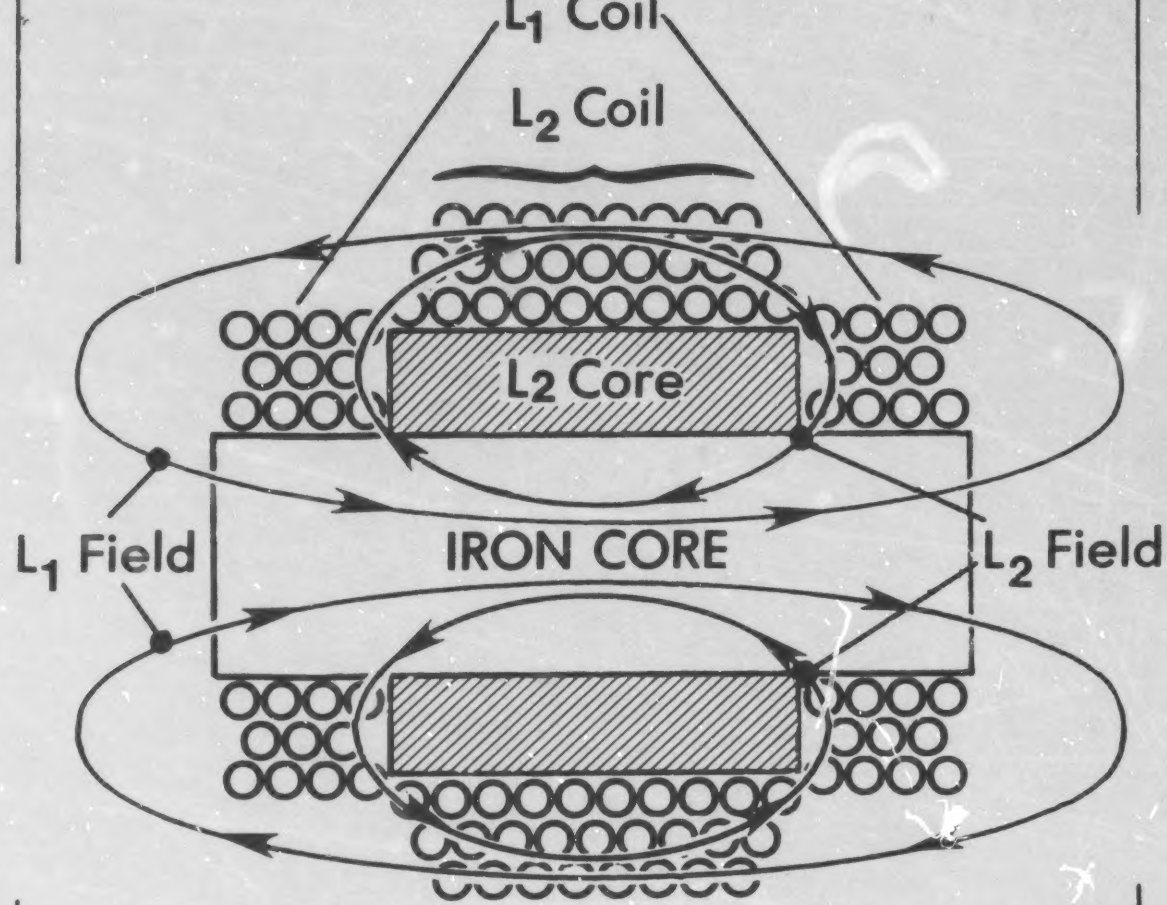
19500

Fig. 95

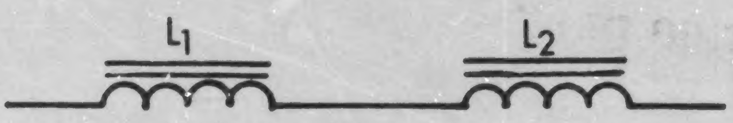
MUTUAL INDUCTANCE


L_M
Δi
L_1
L_2
e_{L_2}
Magnetic Flux

COEFFICIENT OF COUPLING

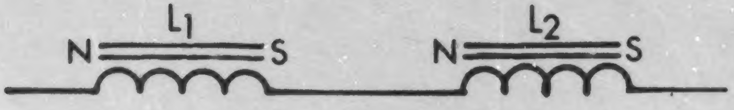

L$_1$ Coil
L$_2$ Coil
L$_2$ Core
L$_1$ Field
IRON CORE
L$_2$ Field

INDUCTORS IN SERIES



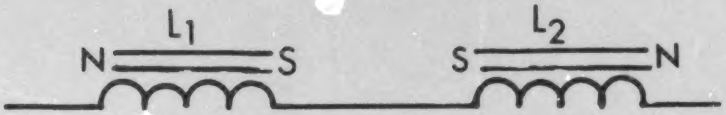
Zero Coupling

$$L_T = L_1 + L_2 \ldots$$



Series Additive

$$L_T = L_1 + L_2 + 2M \qquad M = k\sqrt{L_1 \; L_2}$$

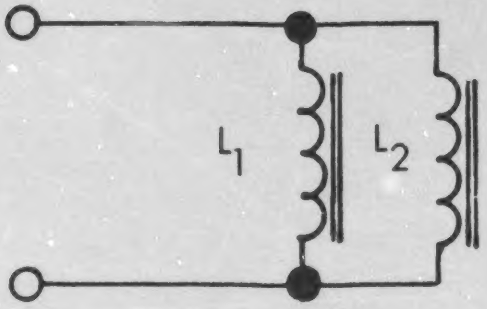


Series Opposing

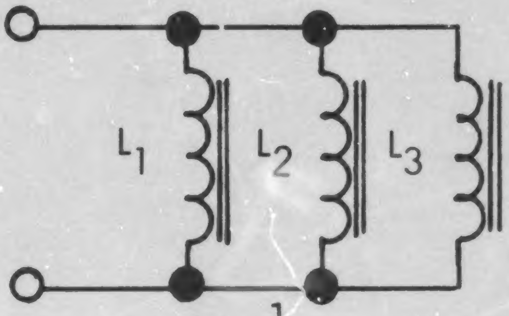
$$L_T = L_1 + L_2 - 2M \qquad M = k\sqrt{L_1 \; L_2}$$

INDUCTORS IN PARALLEL

Zero Coupling Between Coils



$$L_T = \frac{L_1 \; L_2}{L_1 + L_2}$$



$$L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}}$$

Fig. 98

TRANSFORMER RATIOS

Turns = $\frac{T_p}{T_s}$ OR $\frac{n_p}{n_s}$ Voltage = $\frac{E_p}{E_s}$ Current = $\frac{I_p}{I_s}$

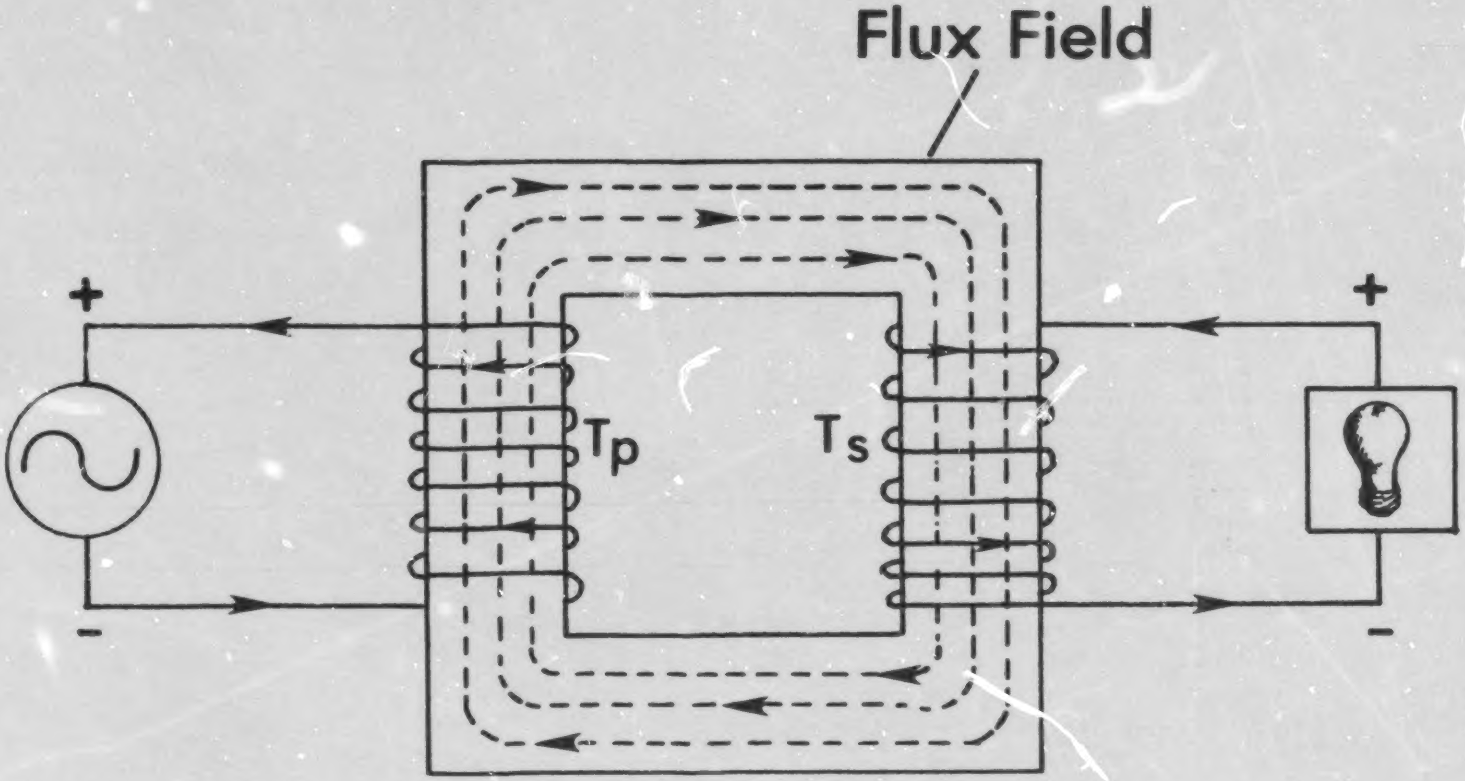

Flux Field
+
-
T_p
T_s
+
-

Fig. 99

INDUCTIVE REACTANCE

FORMULAS:

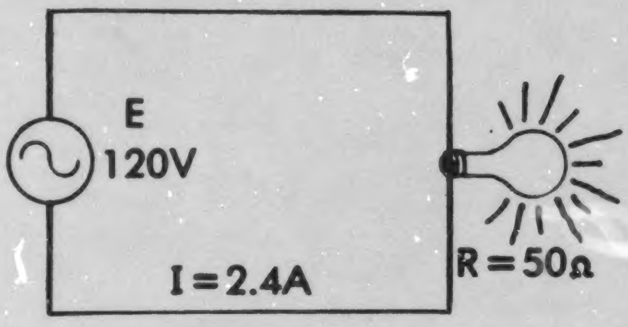
Sine Wave - $X_L = 2\pi fL$

Series - $X_{LT} = X_{L1} + X_{L2}$....

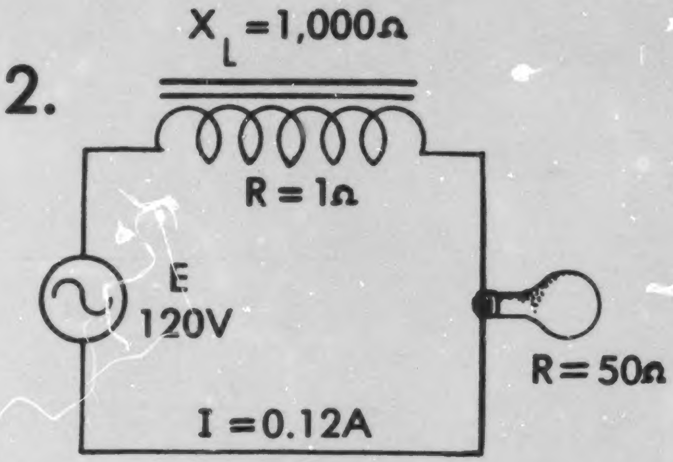
Parallel - $X_{LT} = 1/(1/X_{L1} + 1/X_{L2})$....

Ohm's Law - $X_L = E_L/I_L$

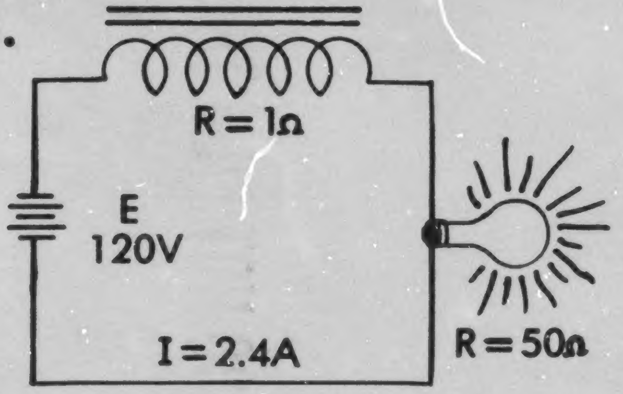
1.


E
120V
I = 2.4A
R = 50Ω

2.


X_L = 1,000Ω
R = 1Ω
E
120V
I = 0.12A
R = 50Ω

3.


R = 1Ω
E
120V
I = 2.4A
R = 50Ω

INDUCTANCE

VI-B-1(AS)
Key

Name ______________________________ Date ____________________________

Directions: Read each statement carefully. Write the word or words which best completes the statements in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

Motion	1. For induction to take place, _____ must take place between the flux and the conductor.
5.00 KA/Second	2. The current in an inductor changes at the rate of 50 mA in 10μ Second. The rate of current change is _____.
10.0 H	3. The inductance of a coil that induces 40 V when its current changes at the rate of 4 A per second is _____.
Permeability	4. Area of each turn, number of turns, length of the coil and ____ of the core are physical characteristics of a solenoid that affect its inductance.
48.0 V	5. The self-induced voltage across a 4 Henry inductance produced by a current change of 12 Ampere per second is _____.
Lenz's	6. _____ Law states that any voltage generated by induction will oppose the motion producing it.
2.00 H	7. The inductance of a coil that produces a self induced voltage of 50 mV when the current varies at the rate of 25 mA/sec is ____.
Mutual	8. The ability of one conductor to induce a voltage in another is called _____ inductance.
Coefficient of Coupling	9. The fraction of the total flux from one coil linking another is called _____.
Tight	10. A high value of k indicated _____ coupling.
One	11. Two coils on a common iron core have a k equal to _____.
80.0 m H	12. If two 400 mH coils have a k equal to 0.200, then L_M will equal _____.
25.0 m H	13. Without L_M, the L_T of 10 mH and a 15 mH coil connected in series would be _____.

Stray	14. The inductance of any wiring not involved in a conventional coil is considered _____ inductance.
0.578	15. A 2 μH coil is connected in series aiding with a 6 μH coil. The total inductance is 12 μH. What is the coupling coefficient?
Turns or Voltage Ratio	16. The amount of voltage step-up or step-down in a transformer is determined by its ____.
Primary	17. The side of a transformer connected to the power source is called the _____.
Secondary	18. The side of a transformer connected to the load is called the ____.
Up	19. When the secondary has more turns than the primary, the transformer is a step _____ transformer.
120 V	20. A power transformer has 100 turns for L_p and 5 turns for L_s. The source voltage is _____ when the load voltage is 6 VAC.
Zero	21. With _____ losses in a transformer, the primary power will equal the secondary power.
Current	22 The ____ ratio of a transformer is the inverse of the turns ratio.
100 mA	23. A transformer with a 6 to 1 voltage step-up ratio has 720 VAC across a 7.2 k Ohm load. The secondary current is ____.
Auto-Transformer	24. A transformer that has no isolation between the primary and the secondary is a/an _____.
Eddy Current	25. Transformer losses due to induced voltage into the core material is called _____ losses.
Laminated Iron	26. To reduce losses in power transformers, _____ is used for the core.
Ferrite	27. At high frequencies, a ceramic material called _____ is used for core material.
50.0 mA	28. A transformer having a 24 V output and loaded with a 48 Ohm resistor will have ____ of primary current when connected to 240 VAC.
Open Primary	29. The current in the primary of a transformer is zero, the problem indicated is ______.

Open Secondary	30. When the primary current is less than normal, the problem indicated is _____.
Opposition	31. Inductive reactance is _____ to AC current flow.
Zero	32. The inductive reactance of an inductor with steady DC through it is _____ Ohms.
Greater	33. The greater the frequency of the AC flowing through an inductor, the _____ the X_L.
75.0 Ohms	34. Calculate the total inductive reactance of three coils connected in series, all having an X_L of 25 Ohms.
8.33 Ohms	35. Calculate the total inductive reactance of three coils in parallel, all having an X_L of 25 Ohms.
Lags	36. In pure inductor, the current _____ the voltage by 90°.
15.9 M Hz	37. At what frequency will a $10 \mu H$ coil have 1 K ohm of inductive reactance?
2.50 K Hz	38. At what frequency will a 10 mH coil have 157 ohms of inductive reactance?
7.50 K Ohms	39. Find the inductive reactance of a coil that has 10 mA flowing through it with 75 V dropped across it.
265 H	40. What size inductor would have a reactance of 100 K Ohms at 60 Hz?
1.57 K Ohms	41. How much inductive reactance will a 6 mH coil have at 41.67 K Hz?
239 u H	42. What value inductor will have 15 K Ohms of X_L at 10 M Hz?
10.6 V	43. If 200 mA peak-to-peak is flowing through an inductive reactance of 150 Ohms, the voltage across it will be ____ RMS.
159 m H	44. What value inductor will have a reactance of 500 Ohms at 500 Hz?
1.21 K Ohms	45. How much reactance will a 320 mH inductor have at 600 Hz?

TEST

VI-B-1(T)
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

D 1. Which of the following will NOT increase the inductance of a coil?
A. Change the core to soft iron.
B. Add more turns on the coil.
C. Increase the core permeability.
D. Increase the amount of current.

A 2. An inductor stores energy in a/an _____.
A. magnetic field
B. electrostatic field
C. induced voltage
D. ion

C 3. Induction occurs when the magnetic field is _____.
A. minimum
B. maximum
C. changing
D. at rest

C 4. What is the inductance of a coil that has 100 Volts induced when the current changes at the rate of 25 A in two seconds?
A. 0.4 H
B. 4.0 H
C. 8.0 H
D. 0.8 H

B 5. A 10 H and a 20 H coil are connected in series aiding with a mutual inductance of 1 H. What is the total inductance of the coils?
A. 64 H
B. 32 H
C. 30 H
D. 15 H

A 6. If a coil induces a voltage in another coil, _____ inductance exists.
A. mutual
B. self
C. aiding
D. opposing

D 7 If a circuit has only inductive reactance,
A. there would be no opposition to current.
B. there would be no current flow.
C. current would lead the voltage by 90°.
D. current would lag the voltage by 90°.

A 8. If the frequency of the current is increased through a coil, the current would _____.
A. decrease
B. increase
C. change to DC
D. remain the same

B 9. What is the voltage-current relationship in an inductive circuit?
A. voltage lags current.
B. current lags voltage.
C. voltage and current are in-phase.
D. voltage leads the current by 180°.

B 10. The symbol X_L represents ____.
A. inductance C. unknown inductance
B. inductive reactance D. coil resistance

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Answers to calculations should have three significant figures and written using the proper metric prefix. Be sure to check your answers.

Relative Motion 11. There must be ____ between a conductor and a magnetic field for induction to take place.

Voltage 12. Lenz's Law states that any ____ generated by induction must oppose the motion that produced it.

Loose 13. A low value of k indicates ____ coupling.

128 V 14. What is the voltage induced across an 8 H coil by a current changing at the rate of 16 A per second?

80.0 m H 15. If two 400 mH coils have a k of 0.2, then the L_M will be ____.

Stray 16. Any undesired inductance is ____ inductance.

Decrease 17. As the frequency of AC is decreased in a coil, the inductive reactance will ____.

Power 18. The ____ in a transformer primary circuit will equal to the secondary circuit.

Secondary 19. The ____ winding of a transformer is connected to the load circuit.

15.9 M Hz 20. A 10 μH coil will have a reactance of 1 K Ohm at a frequency of ____.

Mutual Inductance 21. A transformer is an application of the theory of ____.

Opposition 22. Inductive reactance is the ____ by a coil to AC current flow.

6.00 m H 23. A 10 mH and a 15 mH coil are connected in parallel without L_M, the total inductance is ____.

Leads 24. In a pure inductor, the voltage ____ the current by 90°.

750 Ohms 25. What is the reactance of a coil with 7.5 V across it and 10 mA flowing through it?

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

VI-C-1(I)

SUBJECT:	Capacitance
AIM:	Upon successful completion of the lesson, the student will be able to demonstrate understanding of capacitance, R-C time constants, capacitive reactance and capacitor construction by constructing circuits, making calculations and answering questions.
TEACHING AIDS:	Chalkboard, overhead projector, Transparencies 19500, figs. 101-110
MATERIALS:	Assignment Sheet - Capacitance Experiment # 31 - Capacitance Experiment # 32 - Time Constants Experiment # 33 - Capacitive Reactance Test Sheet - Capacitance
TOOLS AND EQUIPMENT:	Student lab station, component set, oscilloscope
REFERENCES:	DeVito, Introduction to Electricity and Electronics Fowler, Electricity - Principles and Applications Grob, Basic Electronics
PREREQUISITE EXPERIENCE OF THE LEARNER:	All prior lessons

I. PREPARATION (OF THE LEARNER - MOTIVATION)

We have studied resistance and inductance which are basic properties of electronic circuits. Capacitance is the third property we will study. In this lesson we will learn how capacitors can be connected to provide accurate timing using RC time constants. This will be included in this lesson along with capacitive reactance. The old name for a capacitor is condenser.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Capacitance	1. Definitions
Show Transparency fig. 101	a. Simple capacitor: two plates separated by an insulator called a dielectric
	b. Capacitance opposes a change in voltage in a circuit
Show Transparency fig. 102	c. Charging a capacitor

Show Transparency fig. 103

d. Capacitor stores energy in an electrostatic field between plates
e. Symbol: C
f. Unit: Farad, F
g. Most common values in microfarads (uF or MFD) and picofarads (pF)
h. Old unit Micro-micro Farad (uuF) is now pico Farad (pF)
i. Working voltage (WVDC): a specified maximum the capacitor can withstand without damage

Show Transparency fig. 104

j. Color coded values: many types are color coded

B. Characteristics of Capacitors

1. Electrical
   a. Amount of charge the capacitor will accept per volt applied
   b. Formula: C = Q/E (Farads = Coulombs/Volts)
2. Physical

Show Transparency fig. 105

   a. Plate area: larger plates store more electrons

Show Transparency fig. 106

   b. Distance between plates: the closer together the more effect of the static field

Show Transparency fig. 107

   c. Dielectric material: type of material determines the dielectric constant (k)
   d. Formula: $C = k\,A/d$

C. Capacitor Types
Show Transparency fig. 108

1. Variable Types
   a. Rotor-Stator type
   b. Trimmer (compression) type
2. Paper type
   a. Two layers of thin foil separated by waxed paper for dielectric
   b. Band marks outside foil lead
3. Mylar type
   a. Two layers of foil separated by mylar plastic
   b. Band marks outside foil lead
   c. Intermediate values with good voltage ratings (.005 uF to 1 uF)
4. Mica type
   a. Sandwich of metal plates and mica dielectric
   b. Silver mica type uses silver for plates
   c. Small capacitance but high voltage ratings (picofarad)
   d. Very stable in circuit
   e. High cost

5. Disc ceramic
    a. Thin disc of ceramic with metal film deposited on each side for plates
    b. Ceramic material acts as dielectric
    c. Small values and high voltage rating (pF to .1 uF)
    d. Low cost
6. Oil filled
    a. Metal plates with oil as dielectric
    b. Large values and high voltage ratings
    c. High cost

Show Transparency fig. 109

7. Aluminum electrolytic
    a. Electrolyte serves as negative plate
    b. Polarity sensitive
    c. Non-polarized types available for AC circuits
    d. High values (to several thousand uF) with high voltage ratings
    e. High cost for high values

D. Series-Parallel Capacitors

1. Series
    a. Formula: $C_T = 1/(1/C_1 + 1/C_2 \ldots)$
    b. Working voltage adds
2. Parallel
    a. Formula: $C_T = C_1 + C_2 \ldots$
    b. Working voltage equal the smallest in the combination

E. RC Time Constants
Show Transparency fig. 110

1. Time required for a capacitor to charge to 63.2% of the charging voltage or discharge 63.2% from full charge
2. Formula: $t = R \times C$
3. The capacitor is considered fully charged after the 5th time constant

F. Capacitive Reactance

1. Characteristics
    a. Opposition to AC by a capacitor
    b. Caused by the charge and discharge of the capacitor
    c. Symbol: X_C
    d. Unit: Ohms
    e. X_C can reduce current flow in AC circuit
    f. No X_C in DC circuit
    g. Formula: $X_C = 1/(2\pi fC)$

        h. Formula good for sine wave only
2. Series and Parallel X_C
    a. Series: $X_C = X_{C1} + X_{C2} \ldots$
    b. Parallel: $X_C = 1/(1/X_{C1} + 1/X_{C2} \ldots)$
3. Ohm's Law
    a. Formula: $X_C = E_C / I_C$
    b. If voltage is RMS, then current is also RMS
    c. Must use values which apply
4. Phase relationship
    a. Current leads voltage by 90^{o}
    b. ICE
5. Impedance
    a. Total opposition to current by R and X_C in Ohms
    b. Formula: $Z^2 = R^2 + C^2$
    c. Use vector diagram to solve

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

1. Assignment Sheet - Capacitance
2. Experiment # 31 - Capacitance
3. Experiment # 32 - Time Constants
4. Experiment # 33 - Capacitive Reactance
5. Check each student's work for completeness and accuracy
6. Answer any student questions

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

1. Ask oral questions
2. Test Sheet - Capacitance
3. 70% correct is required for satisfactory completion of the lesson

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

1. Discuss test and answer student questions
2. Review the major topics of the lesson presentation

THE NEXT LESSON IS: AC Math

SIMPLE CAPACITOR

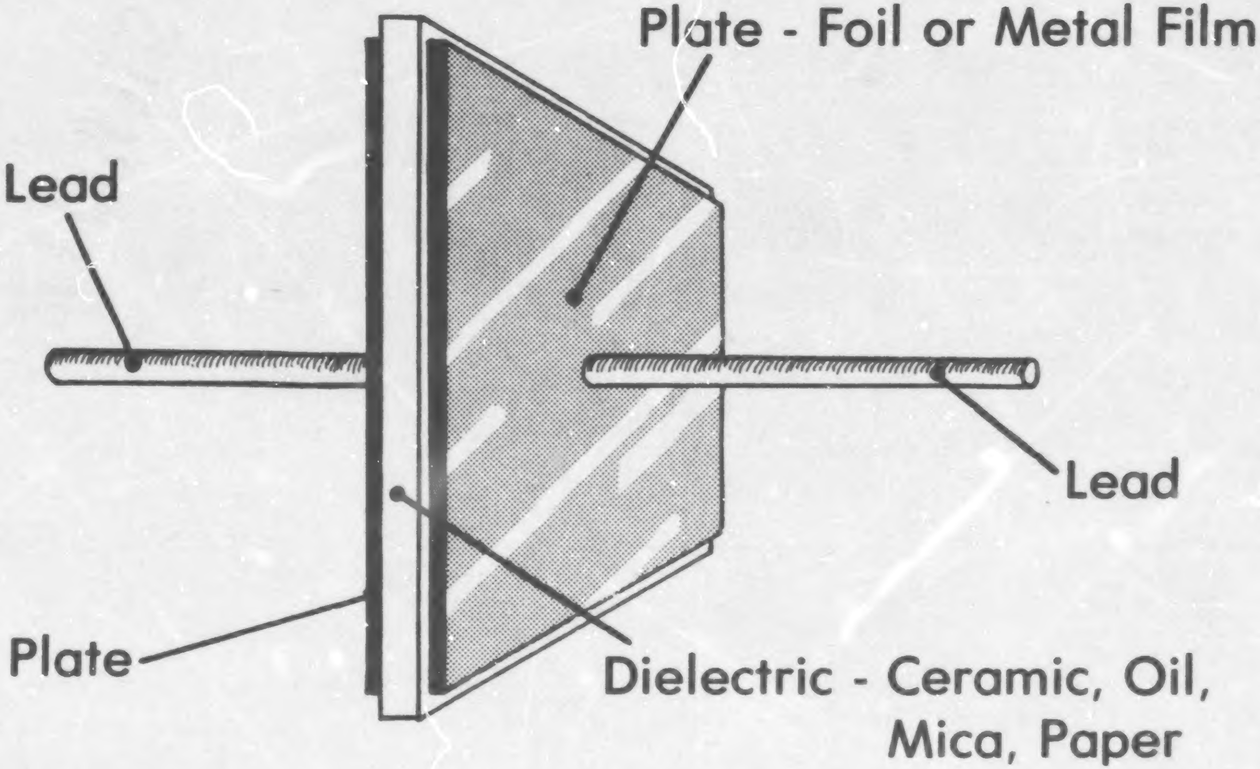
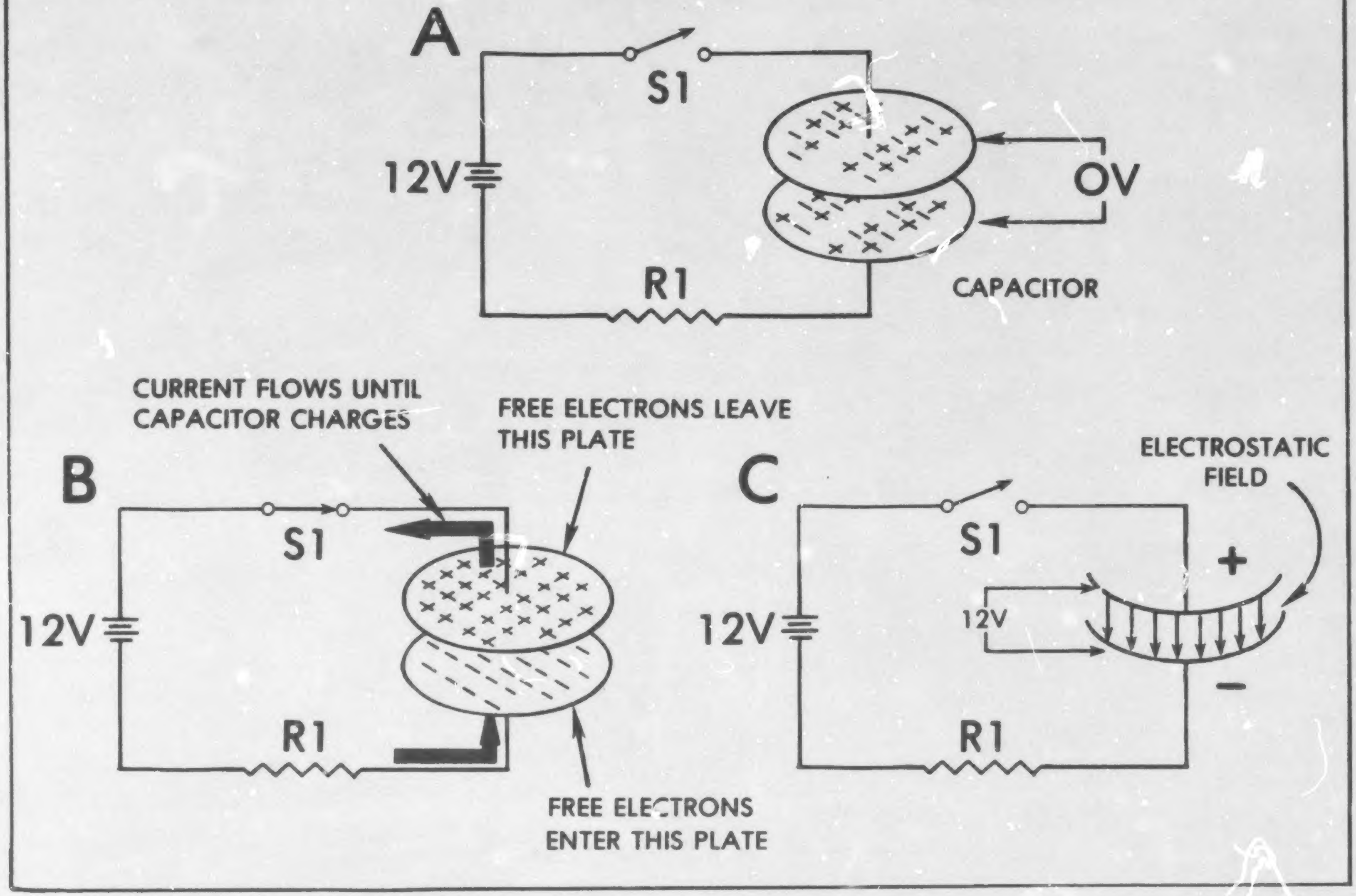


Plate - Foil or Metal Film
Lead
Lead
Plate
Dielectric - Ceramic, Oil, Mica, Paper

Fig. 101

CHARGING A CAPACITOR


A
S1
12V
OV
R1
B
S1
12V
R1
C
S1
12V
12V
+
−
R1

CAPACITOR

CURRENT FLOWS UNTIL CAPACITOR CHARGES

FREE ELECTRONS LEAVE THIS PLATE

FREE ELECTRONS ENTER THIS PLATE

ELECTROSTATIC FIELD

Fig. 102

ELECTRIC FIELD EFFECT ON DIELECTRICS

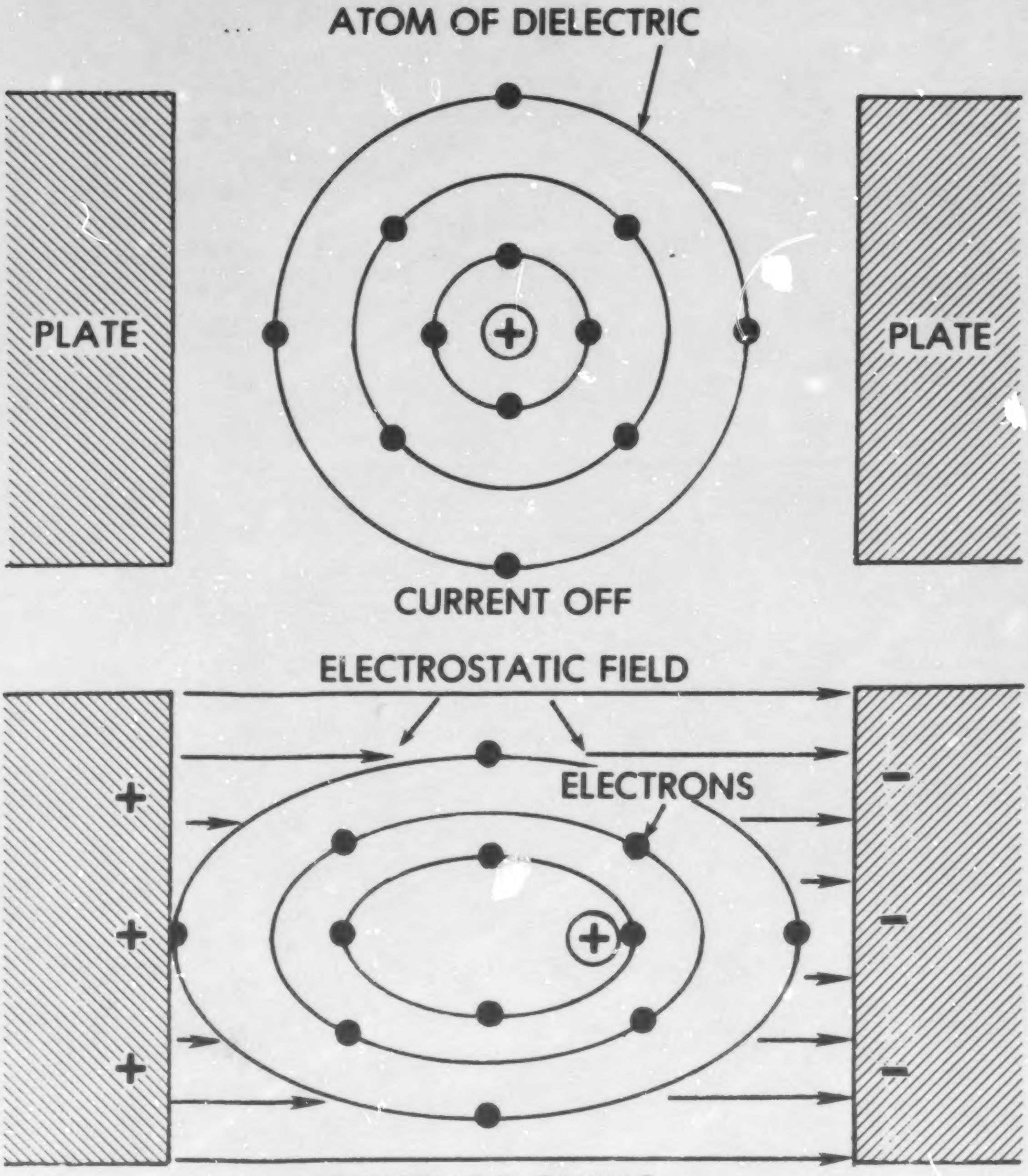

ATOM OF DIELECTRIC
PLATE
PLATE
CURRENT OFF
ELECTROSTATIC FIELD
ELECTRONS
+
+
+
−
−
−
CURRENT FLOWING

Fig. 103

CAPACITOR COLOR CODE

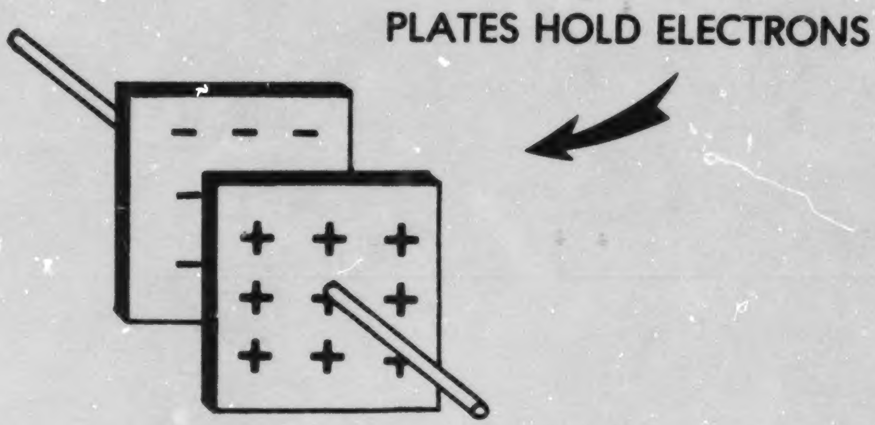
Color	Significant Digit	Decimal Multiplier	Tolerance in %	Voltage Rating
Black	0	1	20	
Brown	1	10	1	100
Red	2	10^2	2	200
Oange	3	10^3	3	300
Yellow	4	10^4	4	400
Green	5	10^5	5	500
Blue	6	10^6	6	600
Violet	7	10^7	7	700
Gray	8	10^8	8	800
White	9	10^9	9	900
Gold		0.1		1000
Silver		0.01		2000
No Color			20	500

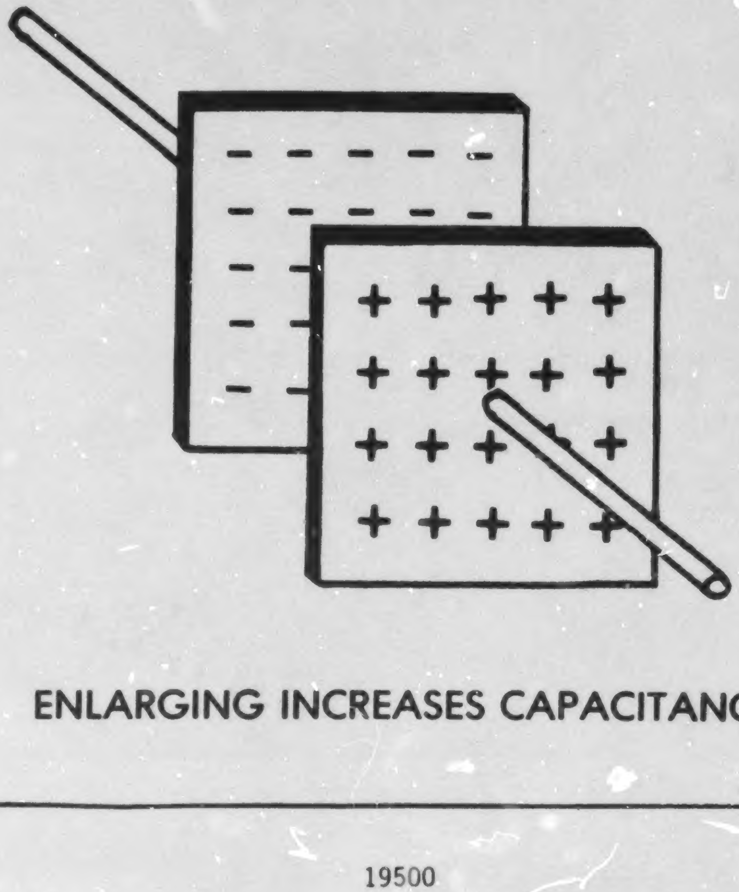
CERAMIC CAPACITOR VALUES

(IN PICOFARADS)

Decimal Multiplier	Tolerance		Temperature Coefficient ppm/°C
	Above 10 pF (in %)	Below 10 pF (in pF)	
1	20	2.0	0
10	1		-30
100	2		-80
1000			-150
			-220
	5	0.5	-330
			-470
			-750
0.01		0.25	30
0.1	10	1.0	500

PLATE AREA AND CAPACITANCE

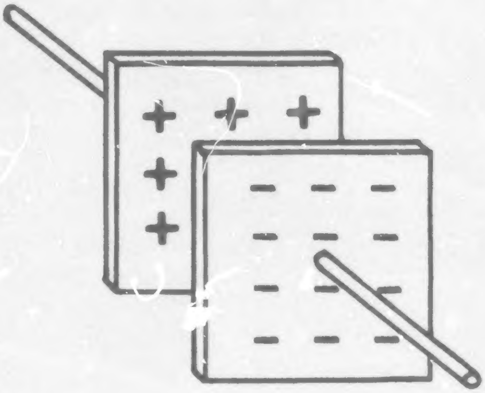

PLATES HOLD ELECTRONS



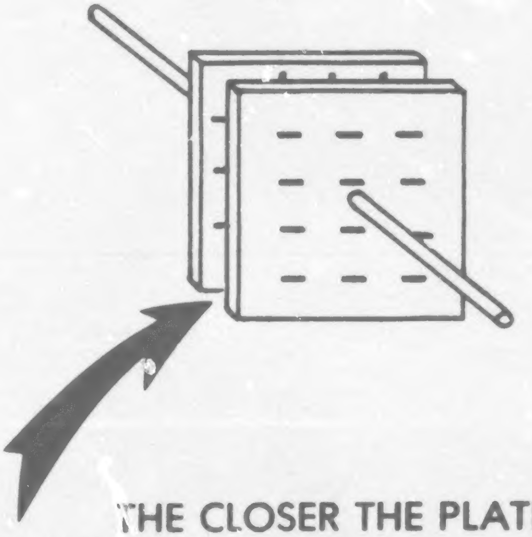
ENLARGING INCREASES CAPACITANCE

PLATE DISTANCE

DISTANCE BETWEEN PLATES IS AN IMPORTANT FACTOR.



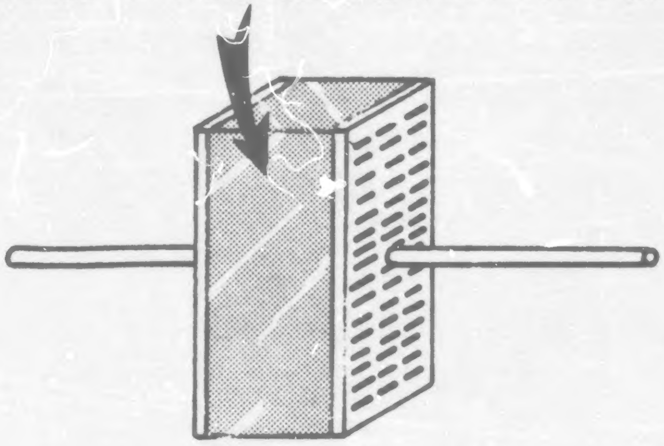
THE DISTANCE BETWEEN TWO CHARGES DETERMINES THEIR EFFECT ON ONE ANOTHER.

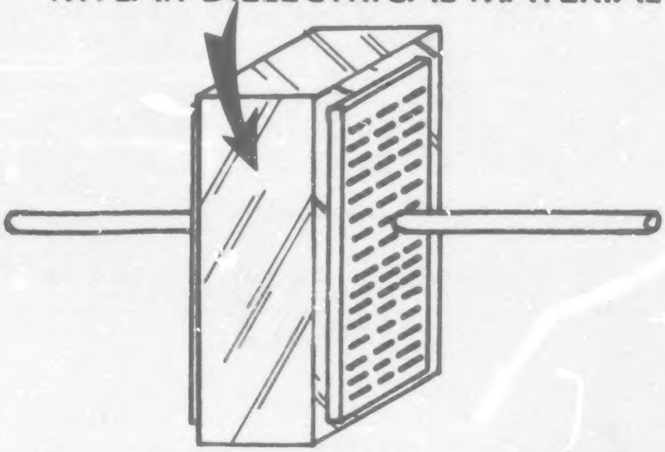


THE CLOSER THE PLATES,
THE GREATER THE CAPACITANCE.

Fig. 106

EFFECT OF DIELECTRIC MATERIALS


WAXED PAPER DIELECTRICAL MATERIAL


MYLAR DIELECTRICAL MATERIAL

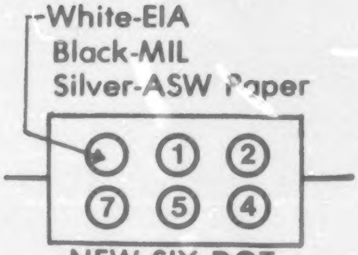
MYLAR INCREASES CAPACITANCE

DIFFERENT DIELECTRIC MATERIALS RAISE OR LOWER CAPACITANCE.

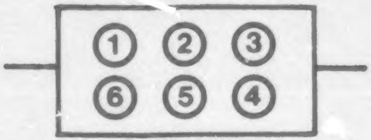
CAPACITOR IDENTIFICATION BY COLOR CODES

1-First Digit
2-Second Digit
3-Third Digit
4-Multiplier
5-Tolerance
6-Working Voltage
7-Classification
8-Blank Indicates Code Type
9-Temperature Coefficient
10-Voltage
  Brown-150
  Orange-350
  Green or Absent-500

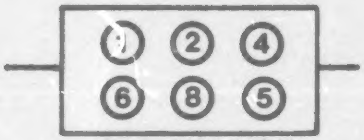
MICA


White-EIA
Black-MIL
Silver-ASW Paper
1 2
7 5 4

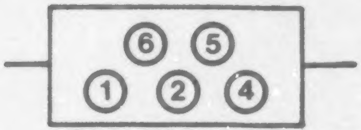
NEW SIX DOT



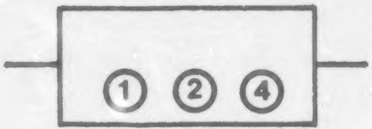
OLD RMA



OLD SIX DOT



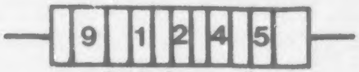
OLD FIVE DOT



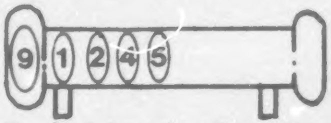
OLD THREE DOT

500 WVDC Rating
± 20% Tolerance

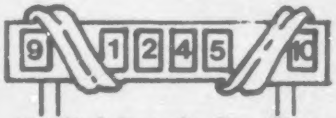
CERAMIC



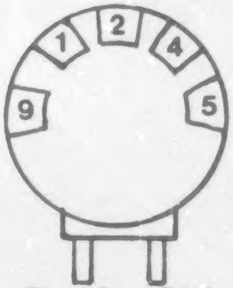
Axial Leads



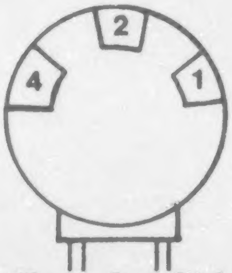
Radial Leads Five Dot



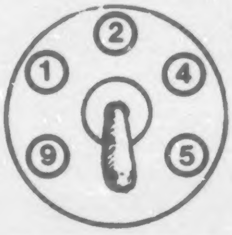
Radial Leads Six Dot



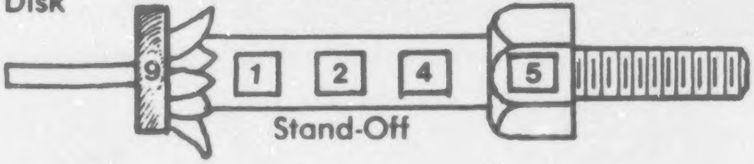
Five Dot Disk



Three Dot Disk



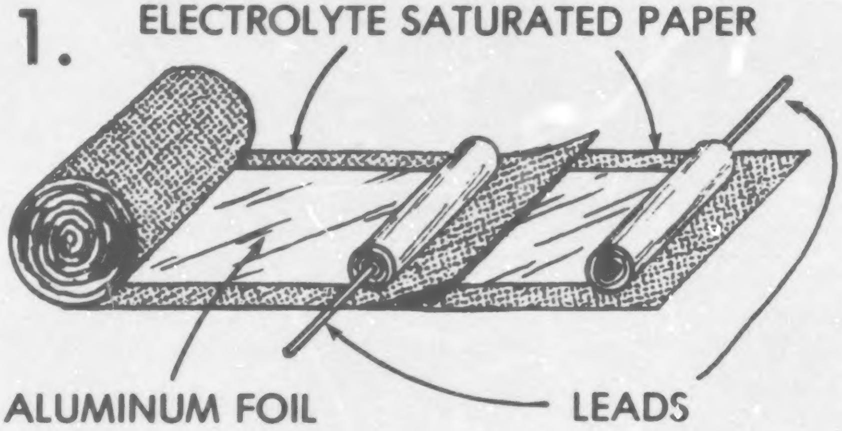
Button Type



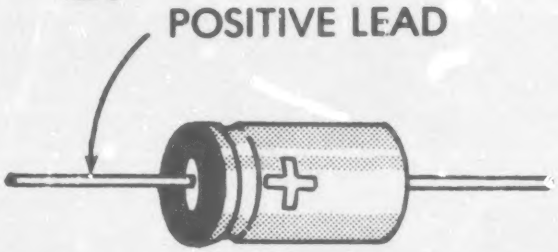
Stand-Off

ELECTROLYTIC CAPACITOR

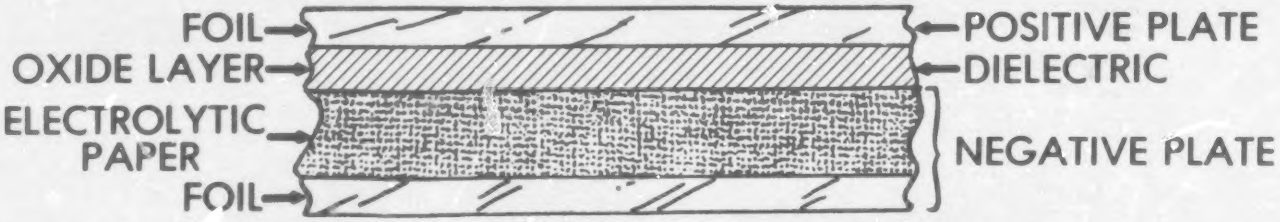
1.


ELECTROLYTE SATURATED PAPER
ALUMINUM FOIL
LEADS

2.


POSITIVE LEAD
+

3.


FOIL
OXIDE LAYER
ELECTROLYTIC PAPER
FOIL
POSITIVE PLATE
DIELECTRIC
NEGATIVE PLATE

19500

Fig. 109

UNIVERSAL TIME CONSTANT GRAPH

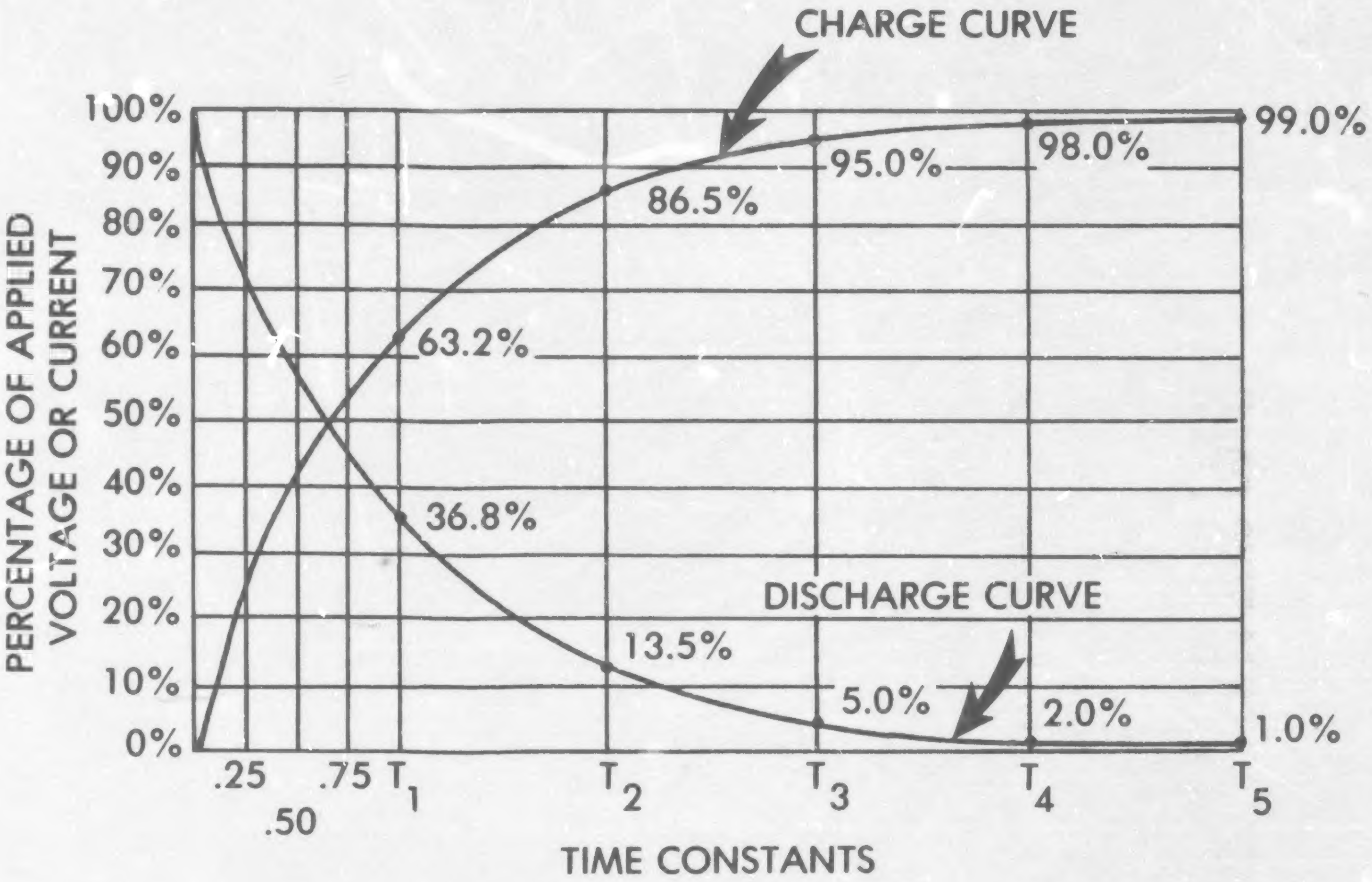


Fig. 110

CAPACITANCE

VI-C-1(AS)
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

Electro-Static Field 1. A capacitor stores energy between its plates in the form of a/an ____.

Dielectric 2. Air, mica and paper are _____ materials used to separate the plates of capacitors.

Capacitor 3. A device consisting of two conductors separated by an insulating material is a/an ____.

Increase 4. Making the plate area of a capacitor larger will ______ the capacitance.

Parallel 5. The largest capacitance can be obtained by placing two capacitors in _____.

Discharged 6. For your safety, capacitors should be _____ before working on circuits.

Outside Foil 7. The band marking on a paper capacitor indicates the lead connected to the _____.

Working Voltage 8. The maximum voltage that can be safely applied across a capacitor is the _____.

Series 9. Two capacitors can be placed in _____ to increase the WVDC.

10.0 u F 10. Three 30 uF capacitors connected in series would have a total capacitance of _____.

90.0 u F 11. Three 30 uF capacitors connected in parallel would have a total capacitance of _____.

Voltage 12. A capacitor opposes a change in ____ in a circuit.

Electrolytic 13. A/an _____ capacitor is polarity sensitive.

C = Q / E 14. The formula for capacitance in electrical terms is _____.

Dielectric 15. In an electrolytic capacitor, the _____ is a very thin layer of aluminum oxide.

t = R x C	16. The formula for finding the time constant of a resistor and capacitor in series is _____.
63.2	17. A capacitor will charge to _____ percent of the applied voltage in one time constant.
200 m Second	18. A 1.0 uF capacitor is charging through a 200 K Ohm resistor from a 10 V source. The time constant is _____.
6.32 V	19. After one time constant, the capacitor in question #18 will be charged to _____.
Five	20. For all practical purposes, a capacitor will be fully charged after _____ time constants.
100 n Second	21. A 1 pF capacitor and a 100 K Ohm resistor have a time constant of _____.
1.05 m Sec	22. A 0.1 uF capacitor and a 10.5 K Ohm resistor have a time constant of _____.
Opposition	23. Capacitive reactance acts as an _____ to AC.
Lags	24. The voltage _____ the current in a pure capacitor by 90°.
300 Ohms	25. If three 100 Ohm capacitive reactances are in series, the total X_C will be _____.
33.3 Ohms	26. If three 100 Ohm capacitive reactances are in parallel, the total X_C will be _____.
More	27. A capacitor has _____ reactance at lower frequencies.
Inversely	28. Capacitive reactance is _____ proportional to capacitance.
100 Ohms	29. What is the capacitive reactance of a 0.016 uF capacitor at a frequency of 100 K Hz?
265 K Ohms	30. A 0.01 uF capacitor is connected across a 10 V, 60 Hz source. The X_C is _____.
300 Ohms	31. A capacitor across a 120 V, 60 Hz source allows 400 mA of current. The X_C is _____.
8.80 u F	32. What is the value of the capacitor in question # 31?
422 p F	33. What size capacitor is needed to have a reactance of 3.77 K Ohms at 100 K Hz?

TEST

VI-C-1(T)
Key

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

A

1. The capacitance of a capacitor is inversely proportional to the
   A. distance between the plates. C. area of the plates.
   B. dielectric constant. D. length of the leads.

C

2. The capacitance of a capacitor is directly proportional to the
   A. distance between the plates. C. area of the plates.
   B. dielectric resistance. D. length of the leads.

C

3. The marked lead on a mylar capacitor should be connected to ____ side of the circuit.
   A. positive B. negative C. low potential

B

4. What will the capacitance of a 10 uF capacitor be if the distance between the plates is doubled?
   A. 10 uF B. 5 uF C. 20 uF D. 0.2 uF

A

5. Alternating current will cause a capacitor to
   A. charge and discharge. C. charge to the RMS value.
   B. charge to the peak value. D. not change.

B

6. How much charge is stored in a 40 uF capacitor with 50 V across it?
   A. 2,000 Coulombs C. 1.25 Coulombs
   B. 2.00 x 10^3 D. 0.800 u Coulomb

C

7. As the frequency increases, the X_C will _____.
   A. increase C. decrease
   B. stay the same D. double

B

8. The capacitive reactance of a 0.1 uF capacitor at 1,000 Hz is _____.
   A. 1 K Ohm B. 1.6 K Ohm C. 2 K Ohms D. 3.2 K Ohms

D

9. Two 1 K Ohm X_C value in series will have a total X_C of _____.
   A. 500 Ohms B. 707 Ohms C. 1,000 Ohms D. 2,000 Ohms

A

10. Two 1 K Ohm X_C value in parallel will have a total X_C of _____.
    A. 500 Ohms B. 707 Ohms C. 1,000 Ohms D. 2,000 Ohms

B

11. The time constant of a 0.5 M Ohm resistor in series with a 2 uF capacitor across a 10 V battery is ____.
    A. 1 u Second B. 1 Second C. 2 Seconds D. 0.5 Seconds

C 12. Five time constants for a 1 pF capacitor and 100 K Ohm resistor in series is _____.

A. 100 u Seconds
B. 100 p Seconds
C. 100 n Seconds
D. 100 Seconds

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Answers to calculations should have three significant figures and written using the proper metric prefix. Be sure to check your answers.

Opposition 13. Capacitive reactance acts as a/an _____ to AC current flow.

0.159 u F 14. What size capacitance is needed for 100 Ohms of reactance at a frequency of 100 K Hz?

Dielectric 15. The insulating material used to separate the plates of a capacitor is called the _____.

Decrease 16. Increasing the distance between the plates of a capacitor will ____ the capacitance.

Increase 17. Increasing the area of the plates of a capacitor will _____ the capacitance.

Working Voltage 18. The maximum voltage that can be safely placed across a capacitor is called the _____.

Zero 19. Once a capacitor in a DC circuit is fully charged, the current will _____.

5.00 mA 20. How much current will flow in a circuit if the reactance is 2 K Ohms and 10 V, 1,000 Hz is applied?

Directions: Read each statement carefully and determine if the statement is true or false. Place a T or F in the space provided to indicate your answer.

T 21. Two conductors separated by space form a capacitor.

F 22. A capacitor stores energy in the plates.

T 23. A Farad is the unit of measure for capacitance.

T 24. Capacitance is increased as the plate area increases.

F 25. Capacitance increases as the distance between the plate increases.

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Wire-Wrap Catalog No. 55548, The Cooper Group, P.O. Box 720, Apex, NC 27502

VICA

Leadership Handbook, VICA, Inc., 105 N. Virginia Ave., Falls Church, VA 22046

The following are all available from: Vocational Instructional Services, F.E. Box 182, Texas A&M University, College Station, TX 77843

Everything You Wanted to Know About VICA
Constitution and Bylaws, VICA Texas Association
Texas VICA Competitive Activities Guide
Initiation Ritual
Official Officer Installation
Handbook for Reporters
Secretary's Notebook
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TX841 3301

FIRST YEAR

STUDENT WORKBOOK FOR VOCATIONAL ELECTRONICS

Written by Chuck Solanik

Illustrated by Mike Harrison

Published by
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VOCATIONAL INDUSTRIAL EDUCATION
TEXAS A&M UNIVERSITY
P. O. BOX 182, COLLEGE STATION, TEXAS 77843

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ACKNOWLEDGEMENT

A sincere note of gratitude to Mr. Chuck Solanik, electronics instructor at John Jay High School in San Antonio, who found time in his busy schedule to compile the materials and develop Vocational Electronics Course of Study.

INTRODUCTION

This Student Workbook I is intended for use with Vocational Electronics Course of Study written by Mr. Chuck Solanik and published by Vocational Services, Texas A&M University.

When using this workbook be sure to follow directions of your instructor. This is also especially important when working experiments in the laboratory. If you are not sure about safety procedures, stop where you are and ask your instructor.

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I-A-1(IS)

INFORMATION SHEET
ON
ELECTRONICS CLASS ORIENTATION

SUBJECT: Course Content and Student Responsibility

INTRODUCTORY INFORMATION:

As students of electronics you should know what we will cover in this course. You should also know what will be expected of you and the system we will use to measure your progress.

GENERAL INFORMATION:

COURSE SUBJECT UNITS

I-A	Orientation
-B	Safety
-C	Mathematics
-D	Leadership
II-A	Components
-B	Measurements
-C	Tools
-D	Soldering
-E	Circuit Construction
III-A	Technical Skills
-B	Life Skills
IV-A	Basic Electricity
-B	Resistance
-C	Ohm's Law and Power
V-A	Series Circuits
-B	Parallel Circuits
-C	Combination Circuits
VI-A	Magnetism
-B	Electromagnetic Devices
VII VII-A	Alternating Current
-B	Inductance
-C	Capacitance
VIII-A	AC Mathematics
-B	R-L-C Circuits
IX-A	Semiconductors
-B	Diodes
-C	Transistors
-D	Special Devices
X-A	Power Supplies
-B	Amplifiers
-C	Oscillators
-D	Other Circuits
XI-A	Digital Intro
-B	Logic Gates
-C	Flip-Flops
-D	Counters and Registers
-E	Digital Circuits
XII-A	Radio and TV Systems
-B	Communications
-C	Instrumentation
-D	Computers
-E	Other Systems

SIX WEEKS GRADES

60% Daily Assignments
- Written assignment
- Task assignment
- Lab experiment
- Pop quiz

40% Tests
- Unit exams
- Completed projects

ABSENCES

Absences should be kept to a minimum. It is your responsibility to come to class and make up all missed work if you are absent. Most work can and should be made up before returning to class. Contact your lab partner for assignments and/or hand out sheets. A pop quiz cannot be made up; however, the lowest daily grade each six weeks will be dropped.

TARDIES

It is your responsibility to be in your seat and ready to begin when the tardy bell rings. There will be no excused tardies. You will be warned on your 1st and 2nd tardy. On your 3rd, you will lose your breaks for 10 days. On each subsequent tardy, you will lose breaks for an additional 10 days and be sent to the Vice Principal's office.

BREAKS

The time between class periods can be used as a break if you wish. It is a good time to stretch, get a drink of water or use the rest room. It is not considered time to stand in the halls, doorway or to horseplay. The taking of breaks is a privilege which can be lost if there are problems.

STUDENT DUTY ASSIGNMENTS

SHOP SUPERINTENDENT

1. Supervises other officers and class members.
2. Greets visitors and offers them safety glasses.
3. Answers the telephone when necessary.
4. Relays reports from the other officers to the instructor.

ASSISTANT SUPERINTENDENT

1. Replaces other officers when they are absent.
2. Assists the tool room manager.

SAFETY SUPERVISOR

1. Checks for unsafe work practices.
2. Checks shop for safety hazards.
3. Greets visitors and offers them safety glasses.
4. Checks equipment to be sure power is off at the end of class.
5. Makes daily report to the shop supervisor and instructor on safety.

TOOL ROOM MANAGER

1. Issues and receives tools and equipment.
2. Improves the tool room.
3. Inventories all tools and equipment at the end of each class.
4. Makes daily report to the shop supervisor on missing or damaged tools.

CLEAN-UP SUPERVISOR

1. Calls for class clean-up.
2. Supervises students in clean-up assignments.
3. Makes daily report to the shop supervisor when all clean-up work is complete.

I-A-1a(IS)

INFORMATION SHEET
ON
GRADING SYSTEM

SUBJECT: Grading System

INTRODUCTORY INFORMATION:

Earlier we spoke of the system we will use to measure your progress. This, of course, means grades, and the following is the method we will use.

GENERAL INFORMATION:

Name ____________ Semester ________ 6 Wks ____ Avg ____

DATE:	DAILY ASSIGNMENTS:	GRADE:	TESTS:	GRADE:
1			1	
2			2	
3			3	
4			4	
5			5	
6			6	
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

TO CALCULATE SIX WEEKS GRADE AVERAGE

1. Calculate daily average = ________
2. Calculate test average = ________
3. Multiply daily average by 0.6 = ________
4. Multiply test average by 0.4 = ________
5. Add results of line 3 and line 4 together = ________
6. Round off and enter at the top of this sheet.

________________ SCHOOL DISTRICT

PARENT PERMISSION FORM

____ - _____ SCHOOL YEAR

This is to certify that my son/daughter, ______________________________, has my full permission to participate in all areas of the Vocational Electronics program at ____________________ High School under the supervision of the instructor, Mr./Ms. ______________________.

I hereby release the ______________________ Independent School District, the school administration, and the instructor involved from any liability for injuries and fatalities suffered by my child while participating in the Vocational Electronics program at ______________________________ High School.

____________________________________ ____________________________

Signature of Parent or Guardian Date

****

STUDENT'S SAFETY STATEMENT FORM

I have received a copy of the shop safety rules for study and insertion in my notebook. I have read and studied the specific safety rules posted on equipment and in the shop.

I fully understand all the safety rules which apply to this shop. I now feel that I am conversant with sufficient safety instruction to warrant my using shop equipment. My knowledge of shop safety is reasonably indicated by the percentage grade on my safety test.

I hereby promise most sincerely to observe all safety rules set up in this shop. Furthermore, I will try to protect others from hazards and accidents and if necessary call the attention of the instructor to any violation of the safety rules.

____________________________________ ____________________________

Signature of the Student Date

____________________________________ ____________________________

Signature of the Instructor Safety Test Grade

INFORMATION SHEET
ON
SAFETY RULES

1. NO HORSEPLAY ---

   It may begin in fun and end in tragedy!

2. CHECK ALL TOOLS AND EQUIPMENT FOR DEFECTS BEFORE USING - - -

   Report anything you feel may be defective to the instructor.

3. DON'T TOUCH ANYTHING YOU DON'T UNDERSTAND - - -

   Ask if you are not sure!

4. STAY DRY AND WELL INSULATED - - -

   Increase your chances of not receiving an electrical shock!

5. SOLDERING IRONS ARE HOT - - BE CAREFUL - - -

   They will burn you and your clothes, care must be taken!

6. ALWAYS WEAR EYE PROTECTION WHEN NEEDED - - -

   Eye protection is required when soldering, unsoldering, sawing, cutting or drilling any material and when handling any chemicals. Molten solder, metal particles and chemicals in the eye can cause blindness.

7. NEVER LIFT HEAVY OBJECTS ALONE - - -

   When you lift a heavy object, keep your body straight and push the body upward with the legs, Get Help!

8. AVOID INHALING VAPORS AND SMOKE - - -

   It can cause lung damage or death!

9. NEVER DEFEAT SAFETY DEVICES - - -

   They are there to protect you!

10. THINK BEFORE DOING!

ASSIGNMENT SHEET

ON

SHOP SAFETY

I-B-1(AS)

Name ______________________________ Date ________________________

Directions: Each studentis to complete this assignment sheet on an individual basis. Read each question carefully before answering. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

List the ten general safety rules which are to be followed in this shop and explain why you feel each is necessary.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

List the three primary factors in determining the severity of an electrical shock.

1. ____________________
2. ____________________
3. ____________________

List three damaging effects other than electrical shock that electricity can have.

1. ____________________
2. ____________________
3. ____________________

Write a brief statement on why it is necessary for every person in this shop area to think safety at all times.

____

____

____

____

ACCIDENT REPORT FORM

Name ______________________ Date ______________________

DIRECTIONS: A report must be made on all accidents. Answer all of the questions completely and accurately. If more space is needed, use the other side of this sheet.

1. Were you involved in the accident or a witness to it?

2. Were there any injuries? If yes, describe them as best you can.

3. Do you feel a safety rule was violated? If yes, which one?

4. Do you feel a new safety rule is needed to prevent another accident of this type?

5. How could the accident have been avoided?

6. Describe what happened in your own words. Be complete, name names, etc.

SCIENTIFIC NOTATION METRIC PREFIXES

1,000,000,000,000	$\times 10^{12}$	TERA	T
1,000,000,000	$\times 10^{9}$	GIGA	G
1,000,000	$\times 10^{6}$	MEGA	M
1,000	$\times 10^{3}$	KILO	K
1	$\times 10^{0}$	UNIT	
001	$\times 10^{-3}$	MILLI	m
.000 001	$\times 10^{-6}$	MICRO	μ
.000 000 001	$\times 10^{-9}$	NANO	n
.000 000 000 001	$\times 10^{-12}$	PICO	p

MATHEMATICS REVIEW

I-C-1a(AS)

Name ______________________________ Date ______________________

A. **DIRECTIONS:** Perform the following operations withouth the use of a calculator. Show all work on a work sheet. Write your final answers in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

ADD:

1.
```
   10,532
       49
      617
    8,052
   98,135
   ______
```

SUBTRACT:

1.
```
   70,605
   61,926
   ______
```

MULTIPLY:

3.
```
   78
   54
   __
```

MULTIPLY:

4.
```
   6,924
     462
   _____
```

DIVIDE:

5.
```
      ________
   93 |651,625
```

B. **DIRECTIONS:** Round off the following numbers to the three significant figures. Be sure to check your answers and write them in the spaces provided. If you have any questions, ask your instructor.

1. 7,206 __________
2. 6,444 __________
3. 98,356 __________
4. 29,755 __________
5. 126,387 __________
6. 4,533,522 __________
7. 28,936 __________
8. 44,363 __________
9. 8,679 __________
10. 2,860 __________
11. 21 __________
12. 211 __________
13. 4906.2222 __________
14. 892.56521 __________
15. 293.94736 __________
16. 7006.7204 __________
17. 42.17647 __________
18. 57.45 __________
19. 0.1388 __________
20. 22.891663 __________
21. 19.52136 __________
22. 796.8287 __________
23. 2.8 __________
24. 0.99328 __________
25. 0.199328 __________
26. 1.5974 __________
27. 1.7203 __________
28. 32.6005 __________
29. 27.7982 __________
30. 36.4554 __________
31. 0.30285 __________
32. 2,512 __________
33. 0.9425 __________
34. 573.5988 __________
35. 188.496 __________
36. 0.0045126 __________
37. 189.999 __________
38. 17.0067 __________
39. 210.561 __________
40. 3.14159 __________
41. 0.00055 __________
42. 2.478 __________
43. 68.4 __________
44. 4.7 __________
45. 0.0009602 __________

C. DIRECTIONS: Perform the following operations. You may use a calculator if you have one. Round off your answers to three significant figures and write them in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

1. 208 + 43 + 6,955 = ________
2. 71 + 979 + 856 = ________
3. 3,594 + 2,216 + 634 = ________
4. 8,015 + 32 + 500 + 4 = ________
5. 87,645 + 923 + 9,769 = ________
6. 4,379 + 5,083 + 9,752 = ________
7. 67,841 + 80,936 + 245 = ________
8. 264 + 58,198 + 4,589 = ________
9. 46 - 25 = ________
10. 94 - 32 = ________
11. 725 - 687 - 25 - 2 = ________
12. 950 - 63 - 34 = ________
13. 58,761 - 14,398 = ________
14. 70,605 - 61,679 - 210 = ________
15. 8,432 - 853 - 2,134 = ________
16. 82,570 - 52,491 - 999 = ________
17. 493 x 7 = ________
18. 8,210 x 9 = ________
19. 154 x 82 = ________
20. 209 x 17 x 63 = ________
21. 853 x 63 x 54 = ________
22. 7,613 x 54 x 10 = ________
23. 6,975 x 493 x 3 = ________
24. 96 x 7 x 493 x 3 = ________
25. 322 / 7 = ________
26. 44,156 / 9 = ________
27. 2[illegible],529 / 23 = ________
28. 717 / 24 = ________
29. 75 / 33 = ________
30. 61,051 / 3,007 = ________
31. 651,615 / 19 = ________
32. 7,035 / 48 = ________
33. 24.6 + 32.85 = ________
34. 168.5 + 0.123 = ________
35. 0.0002 + 0.1368 = ________
36. 0.002 + 7.46 + 123 = ________
37. 12.6 - 9.8 = ________
38. 93.25 - 6.42 = ________
39. 108.4362 + 99.5862 = ________
40. 0.00068 - 0.00032 = ________
41. 163 x 0.2 = ________
42. 176 x 0.25 = ________
43. 0.678 x 41 = ________
44. 3.87 x 9.42 = ________
45. 67.3 x 0.0045 = ________
46. 0.00275 / 5 = ________
47. 17½% of 350 = ________
48. 1 % of 1,975 = ________
49. 80% of 56 = ________
50. 45% of 26 = ________

SCIENTIFIC NOTATION

Name ______________________ Date ____________________

DIRECTIONS: Perform the following operations and round off your answers to three significant figures. Answers that are to be written in scientific notation should be written as a number between 1 and 10 times ten to a power. Example: 3.45×10^3. Write your answers in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

A. Convert to Scientific Notation:

1. 142.53 = ____________
2. 150,000 = ____________
3. 0.00336 = ____________
4. 4,663,310.56 = ____________
5. 86,400 = ____________
6. 0.12500 = ____________
7. 0.00125 = ____________
8. 0.000000000000144 = ____________
9. 65,500,000,000,000 = ____________
10. 0.000006835 = ____________

B. Convert to Standard Notation:

11. $1.63 \times 10^7 =$ ____________
12. $4.781354 \times 10^3 =$ ____________
13. $1.01 \times 10^6 =$ ____________
14. $9.81 \times 10^1 =$ ____________
15. $3.1145 \times 10^{-4} =$ ____________
16. $6.5545 \times 10^{12} =$ ____________
17. $8.001 \times 10^{-5} =$ ____________
18. $9.34512 \times 10^{-6} =$ ____________
19. $6.28 \times 10^6 =$ ____________
20. $3.1415926 \times 10^0 =$ ____________

C. Solve the Following:

21. $(1.60 \times 10^2) + (3.20 \times 10^2) =$ ____________________
22. $(1.50 \times 10^2) + (1.50 \times 10^3) =$ ____________________
23. $(3.20 \times 10^3) + (2.00 \times 10^2) =$ ____________________
24. $(3.40 \times 10^{-3}) + (1.60 \times 10^{-4}) =$ ____________________
25. $(3.20 \times 10^2) - (1.60 \times 10^2) =$ ____________________
26. $(1.50 \times 10^3) - (1.50 \times 10^2) =$ ____________________
27. $(3.20 \times 10^3) - (2.00 \times 10^2) =$ ____________________
28. $(3.40 \times 10^{-3}) - (1.60 \times 10^{-4}) =$ ____________________
29. $(1.50 \times 10^2) \times (1.50 \times 10^{-2}) =$ ____________________
30. $(3.20 \times 10^6) \times (5.20 \times 10^{-3}) =$ ____________________

31. $(1.60 \times 10^{0}) \times (4.80 \times 10^{1}) =$ ______________________

32. $(9.30 \times 10^{-6}) \times (2.80 \times 10^{3}) =$ ______________________

33. $(0.000256) / (0.000000338) =$ ______________________

34. $(0.000000857) / (856{,}000{,}000) =$ ______________________

35. $(156{,}000 \times 10^{4}) / (67.6 \times 10^{-3}) =$ ______________________

36. $(5.36 \times 10^{-5}) / (0.0000845) =$ ______________________

37. $\sqrt{16.0 \times 10^{5}} =$ ____________ 39. $\sqrt{23.0 \times 10^{9}} =$ ____________

38. $\sqrt{756 \times 10^{7}} =$ ____________ 40. $\sqrt{23.5 \times 10^{13}} =$ ____________

41. $\dfrac{4{,}914{,}000}{0.0078 \times 63{,}000} =$ ______________________

42. $\dfrac{0.000256 \times 0.000000338}{865{,}000{,}000} =$ ______________________

43. $\dfrac{156{,}000 \times 10^{4} \times 248 \times 10^{6}}{67.0 \times 10^{-3}} =$ ______________________

44. $\dfrac{704 \times 10^{-6} \times 485{,}000 \times 10^{3}}{573 \times 10^{-8} \times 6.28 \times 10^{12}} =$ ______________________

45. $\dfrac{1 \times 10^{0}}{6.28 \times 60 \times 25 \times 10^{-6}} =$ ______________________

46. $\dfrac{0.0022 \times 600}{3.00 \times 10^{-10}} =$ ______________________

47. $\dfrac{5.00 \times 10^{-5} \times 2400}{0.00008 \times 3.00 \times 10^{10}} =$ ______________________

48. $\dfrac{6.02 \times 10^{23} \times 1.60 \times 10^{-19}}{16.0 \times 10^{-2}} =$ ______________________

49. $\dfrac{0.000004532 \times 10^{6} \times 16{,}502 \times 10^{3}}{1{,}532 \times 10^{3} \times 8{,}415 \times 10^{-6}} =$ ______________________

50. $\dfrac{653{,}200 \times 10^{-1} \times 8{,}413 \times 10^{0}}{48.0 \times 10^{2} \times 0.003 \times 10^{1}} =$ ______________________

METRIC PREFIXES

Name ______________________________ Date ________________________

DIRECTIONS: Make the following conversions and write the answers in the spaces provided. Be sure to check your answers. If you have any questions, ask your instructor.

____________________ 1. Change 27.1 microhenrys to Henrys. (Inductance)

____________________ 2. Change 0.00271 Henrys to microhenrys. (Inductance)

____________________ 3. Change 950 Hertz to kilohertz. (A. C. Frequency)

____________________ 4. Change 0.00015 microfarad to Farads. (Capacitance)

____________________ 5. Change 2.7×10^{-12} Farads to picofarads. (Capacitance)

____________________ 6. Change 4.6 megohms to Ohms. (Resistance)

____________________ 7. Change 33.5 millivolts to Volts. (Voltage)

____________________ 8. Change 2,265 milliwatts to Watts. (Power)

____________________ 9. Change 4.56×10^{-5} Volts to microvolts. (Voltage)

____________________ 10. Change 0.035 millihenrys to microhenrys. (Inductance)

____________________ 11. Change 3.25 microvolts to millivolts. (Voltage)

____________________ 12. Change 100 picofarads to microfarads. (Capacitance)

____________________ 13. Change 2.46 megahertz to kilohertz. (A. C. Frequency)

____________________ 14. Change 5 kilovolts to millivolts. (Voltage)

____________________ 15. Change 19 microfarads to picofarads. (Capacitance)

____________________ 16. Change 0.000001 Seconds to microseconds. (Time)

____________________ 17. Change 3,230 Watts to kilowatts. (Power)

____________________ 18. Change 5×10^{7} Ohms to megohms. (Resistance)

____________________ 19. Change 1.45 megohms to kilohms. (Resistance)

____________________ 20. Change 0.00056 Seconds to milliseconds. (Time)

____________________ 21. Change 1.02 kilohertz to Hertz. (A. C. Frequency)

____________________ 22. Change 0.018 nanoseconds to picoseconds. (Time)

____________________ 23. Change 0.098 Amperes to milliamperes. (Current)

____________________ 24. Change 0.0684 milliampere to microampere. (Current)

____________________ 25. Change 0.0001 microfarad to picofarad. (Capacitance)

____________________ 26. Change 3,500 Ohms to kilohms. (Resistance)

DIRECTIONS: Complete the following chart.

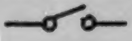
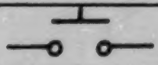
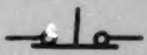
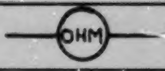
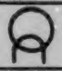
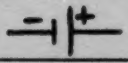
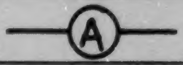
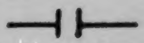
UNITS	SCIENTIFIC NOTATION	METRIC PREFIXES
0.25 Ampere	27.	28.
29.	3.00×10^6 Ohms	30.
31.	32.	5 p Farad
5,000 Volts	33.	34.
35.	1.70×10^{-3} Henry	36.
37.	38.	6 μ Farad
7,000,000,000 Hertz	39.	40.
41.	2.00×10^{-9} Second	42.
43.	44.	47 K Volts
0.0001 Ampere	45.	46.
47.	1.00×10^3 Ohms	48.
49.	50.	150 M Hertz

COMPONENTS AND SYMBOLS

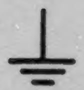
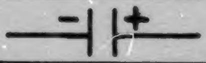
II-A-1a(AS)

Name ______________________________ Date ________________________

DIRECTIONS: Each student will complete this assignment sheet on an individual basis. Fill in the blanks with the proper component name, graphic symbol or letter symbol. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

	COMPONENT NAME	GRAPHIC SYMBOL	LETTER SYMBOL
1.	Fuse		
2.			
3.	Switch, Single Pole, Double Throw		
4.	Coil, Iron Core		
5.			
6.	Switch, Double Pole, Double Throw		
7.	Switch, Double Pole, Single Throw		
8.			
9.	Voltmeter		
10.			
11.	Resistor, Fixed		
12.			
13.	A. C. Generator		
14.			
15.			
16.	Potentiometer		
17.			
18.	Battery		

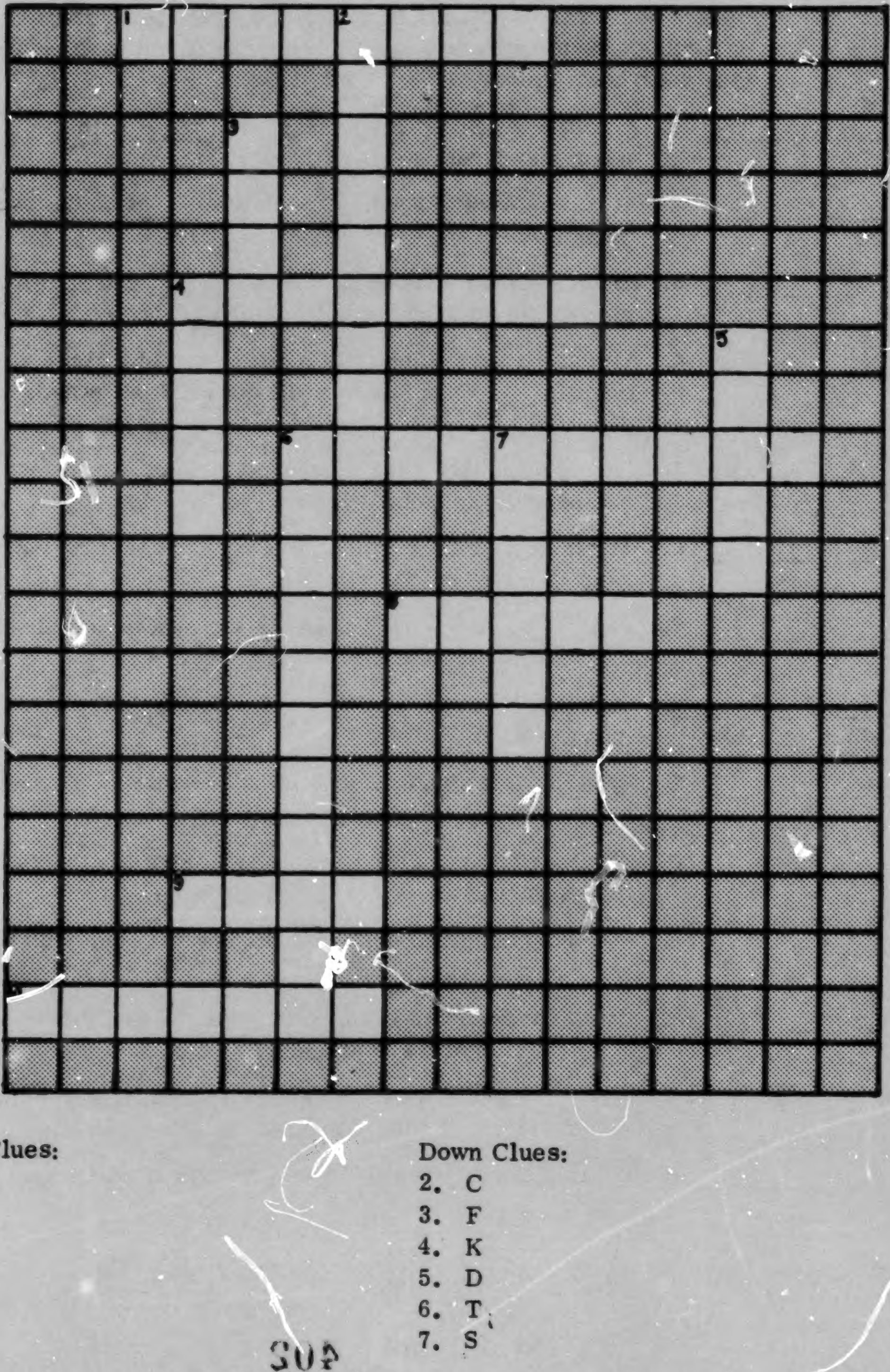
004

19.		
20. Rheostat		
21.		
22. Diode		
23. Variable Capacitor		
24. Iron Core Transformer		
25. Transistors NPN & PNP		

LETTER SYMBOLS

II-A-1b(AS)

Name ______________________________ Date ______________________________


1
2
3
4
5
6
7
8
9
10

Across Clues:
1. L
4. R
6. Q
8. M
9. LP
10. B

Down Clues:
2. C
3. F
4. K
5. D
6. T
7. S

SOP

METER MEASUREMENTS

II-B-1(AS)

Name ______________________________ Date __________________________

DIRECTIONS: This assignment sheet is to be completed on an individual basis. Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Check all your answers to be sure they are correct. If you have any questions, ask your instructor.

__________________ 1. A voltmeter is always connected in _____ with the circuit being measured.

__________________ 2. An ammeter is always connected in ____ with the circuit being measured.

__________________ 3. Always set a meter to the highest _____ setting before measuring an unknown voltage or current.

__________________ 4. Always be sure to connect a meter in the circuit with the correct ____ so the meter will not read backwards and be damaged.

__________________ 5. For your safety, care must be taken not to ____ more than one point in a circuit with a meter probe.

__________________ 6. An ammeter can be ruined instantly if connected across a/an ____.

__________________ 7. The ____ switch on a VOM sets the maximum value which can be measured at that setting.

__________________ 8. On a multimeter, the ____ switch determines what is to be measured.

__________________ 9. A/an ____ requires several minutes of warm-up time before it can be used for measurements.

__________________ 10. For your safety, always connect meters to circuts with the power turned ____ if at all possible.

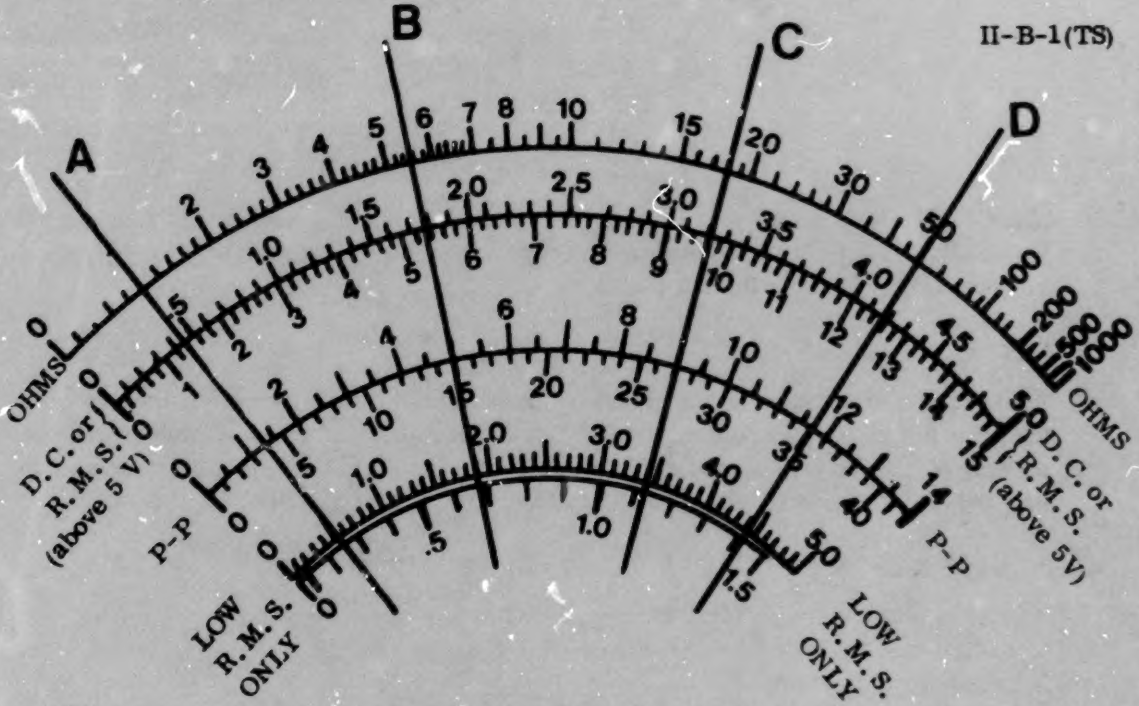
__________________ 11. The most accurate voltage readings are obtained at the _____ portion of the scale.

__________________ 12. The most accurate resistance readings are obtained at the _____ portion of the scale.

__________________ 13. The ____ control must be set before making a resistance measurement to insure a more accurate reading.

__________________ 14. To insure a greater accuracy, always read a meter when looking ____ at its face.

__________________ 15. Always handle meters ______, they are delicate and expensive instruments.


A
B
C
D
OHMS
0
2
3
4
5
6
7
8
10
15
20
30
50
100
200
500
1000
OHMS
D. C. or R. M. S. (above 5 V)
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
D. C. or R. M. S. (above 5V)
P-P
0
10
20
25
30
35
40
P-P
LOW R. M. S. ONLY
1.0
2.0
3.0
4.0
5.0
.5
1.5
LOW R. M. S. ONLY

Directions: Complete the chart using the meter scale and pointers in figure 1. If you have any questions, ask your instructor.

Function	Range	Pointer A	Pointer B	Pointer C	Pointer D
DCV	15				
ACV	500				
Ohms	x100				
DCV	5				
ACV	1.5				
Ohms	x10K				
DCV	50				
ACV	150				
Ohms	x10				
DCV	500				
ACV	1500				
Ohms	x100K				
DCV	150				
ACV	5				
Ohms	x1M				
DCV	1.5				
ACV	50				
Ohms	x1K				

SAFETY RULES FOR USING TOOLS

II-C-1(IS)

1. USE THE RIGHT TOOL FOR THE JOB YOU ARE DOING

   Most tools are specialized. Using them outside of that speciality is tool misuse. Don't add "cheaters" to increase leverage. Use screwdrivers to turn screws -- not open cans or substitute for chisels.

2. DON'T USE BROKEN OR DEFECTIVE TOOLS

   Tools that are cracked or worn should be repaired or replaced. Worn power cords are a sign of impending trouble and should be replaced. Only experienced personnel should make repairs on tools or shop equipment. If a strange sound in a tool tells you something is wrong, believe it.

3. KEEP TOOLS IN GOOD REPAIR AND PROPERLY STORED

   Neatness and safety go hand in hand. Every tool should have its place when not in use. Keep the work area tidy, don't use work benches for tool storage. Professionals take care of tools.

4. WEAR EYE PROTECTION WHEN SOLDERING, DRILLING, CUTTING, ETC.

   Never, never risk your eyes by failure to use safety glasses or goggles. Use eye protection and other protection whenever there is a possibility of being struck by flying tools, parts, chemicals, or metal chips.

5. BE SURE POWER TOOLS ARE PROPERLY GROUNDED

   Use power tools only if they have three wire grounding cords or are double insulated. Never use three to two wire adapters without first connecting the ground wire.

6. SLOW DOWN AND THINK ABOUT SAFETY

   Use your head! A moment of thought may save your eye, your finger, your life. Never overcome safety devices. Never mix horseplay with tools or machines. If an accident does occur, get competent medical help at once.

* Source: Jensen Tool Company

TOOL SAFETY

Name ______________________________ Date __________________________

DIRECTIONS: Each student is to complete this assignment sheet on an individual basis. List the six safety rules for hand tools which are to be followed in this shop and explain why you feel each is necessary. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

1. ____

2. ____

3. ____

4. ____

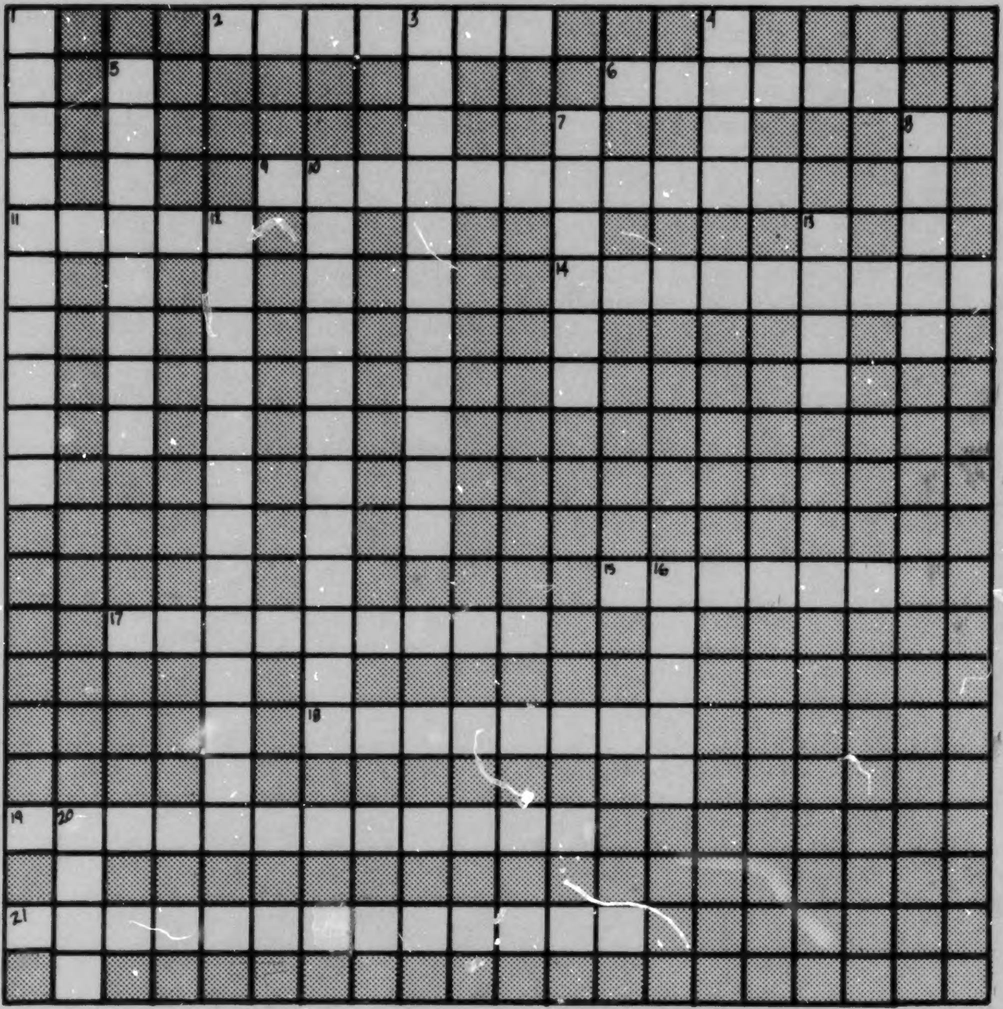
5. ____

6. ____

TOOLS

II-C-1b(AS)

Name ______________________________ Date ______________________________



Across Clues:

2. Cuts metal
6. Channel locks
9. Not for prying
11. Make the job easier
14. Tightens nuts
15. For hitting
17. Wire cutters
18. Pointed pliers (2 words)
19. Removes insulation (2 words)
21. Melts metal alloy (2 words)

Down Clues:

1. Cuts holes (2 words)
3. Helps prevent accidents (2 words)
4. Has teeth and tang
5. Locking pliers
7. For tuning bolts
8. Measure
10. Apply terminals (2 words)
12. Eye protection (2 words)
13. Holds work
16. Hex shape
20. Melts solder

SOLDERING

II-D-1(AS)

Name ______________________ Date ____________________

DIRECTIONS: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Check your answers to be sure they are correct. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

______________ 1. The process of _____ is used in electronics to make reliable component connections.

______________ 2. The bond that takes place between solder and other metals is called _____.

______________ 3. The _____ ratio determines the melting temperature of solder.

______________ 4. The solder alloy most commonly used in electronics is _____.

______________ 5. Most solder melts at a temperature of approximately ____ °F.

______________ 6. The chemical cleaning of oxide from metal parts is done using solder _____.

______________ 7. Only ____ solder flux can be used for electronics and electrical work.

______________ 8. Most soldering of electronic components is done with an ____ style soldering iron.

______________ 9. A soldering iron with a ____ watt rating should be used to prevent component damage.

______________ 10. With its instant high heat feature, a soldering ____ can damage small components.

______________ 11. To make consistently good connections, you should ____ your soldering iron tip each time you pick it up.

______________ 12 Good solder connections should look ____ and shiny.

______________ 13. Most bad solder connections are caused by excessive ____ or not enough heat.

__________ 14. Always wear ____ when soldering or cutting wire.

__________ 15. Two common methods of desoldering are the flux coated ____ and the vacuum bulb.

__________ 16. To prevent severe ____, be careful handling hot soldering irons.

__________ 17. A solder connection should not be moved during the ____ time.

__________ 18. Wire insulation, circuit boards and semiconductors are easily ____ by heat.

DIRECTIONS: List the seven steps required to safely make good solder connection in the following spaces.

19. ______________________________

20. ______________________________

21. ______________________________

22. ______________________________

23. ______________________________

24. ______________________________

25. ______________________________

SOLDER PRACTICE BOARD

II-D-1(TS)

Name ______________________ Date ______________________

DIRECTIONS: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed. If you have any questions or problems, ask your instructor.

Safety Note:
* Eye protection MUST be worn when soldering and cutting wire.
* Soldering irons are HOT and will burn. BE CAREFUL!

______ 1. Fasten the six lug terminal strips to the component side of the circuit board using the 1/8" x 1/8" "Pop Rivets".

______ 2. Using #22 AWG solid, tinned copper wire, make connections between adjacent terminals as demonstrated. Continue to make and remake the connections until all are acceptable connections.

______ 3. Using the wire strippers, remove about 1/2" of insulation from the end of a piece of #22 AWG stranded wire. Tin the wire. Cut the wire so the overall length is about 1 1/2". Repeat this until you have 6 acceptable pieces tinned.

______ 4. Connect and solder each of these pieces to a terminal. Use the example board to determine which of the terminals to use.

______ 5. Using #22 AWG solid, tinned copper wire, make 18 jumper wires to fit between the pad pairs #1 through #18.

______ 6. Install the jumper wires in pad pairs #1 through #6. Solder and trim the excess lead length.

______ 7. Install the jumper wires in pad pairs #7 through #18. Solder and trim the excess lead length. Desolder and remake all unacceptable connections.

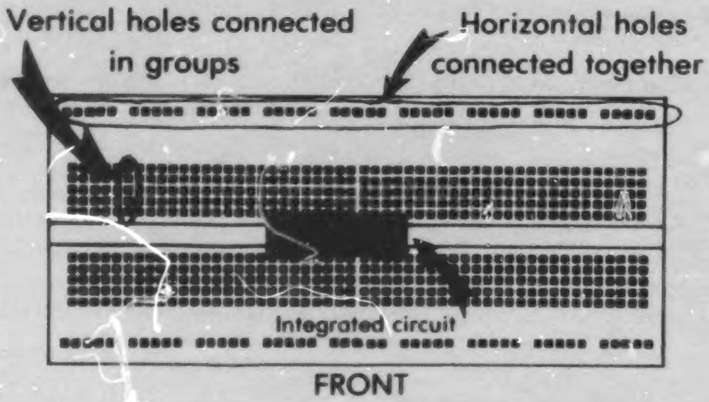
______ 8. Using #24 AWG solid, tinned copper wire, make 40 jumper wires to fit between the pad pairs A through E.

______ 9. Install the jumper wires in the A section pad pairs. Solder and trim the excess lead length.

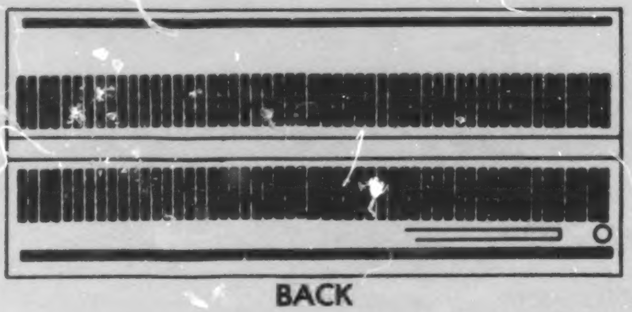
______ 10. Install the jumper wires in the B section pad pairs. Solder and trim the excess lead length. Desolder and remake all unacceptable connections.

______ 11. Install the jumper wires in the remaining pad pairs. Solder and trim the excess lead length. Desolder and remake all unacceptable connections.

One of the most useful devices in experimental electronic circuit construction is the solderless breadboard or socketboard. It allows for fast, easy construction for testing, and when the circuit is perfected, it can be built more permanent by using a printed circuit board or soldered wiring.


Vertical holes connected in groups
Horizontal holes connected together
Integrated circuit

FRONT



BACK

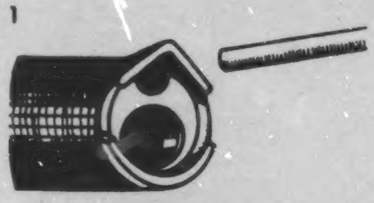
Note the holes in the front of the protoboard which accept component leads. Holes in the horizontal lines are connected on both top and bottom on the back of the board. Components with leads plugged into these strips are thus connected together. This approach is used for vertical hole groups of 5 per each. Component leads up to a maximum of five plugged into these holes will be connected together.

The center channel divides the protoboard and integrated circuits straddle the channel. A component bracket holding lamps, terminals, etc. can be placed in the channel on each edge of the board. Components producing heat should not be placed close to the plastic surface. Solid wire from #20 to #24 AWG should be used.

Wire-Wrap Connection Procedure

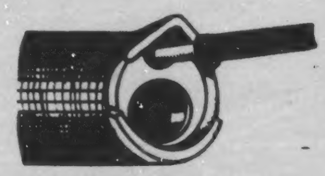
Source: The Cooper Group P.O.Box 728 Apex, NC 27502

STEP 1



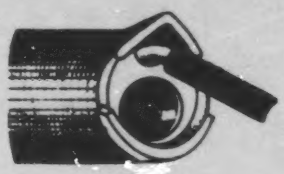
Components: Bit, Sleeve, Stripped Wire

STEP 2



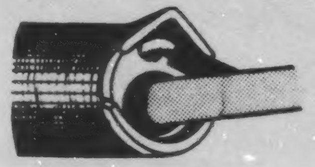
Insertion

STEP 3



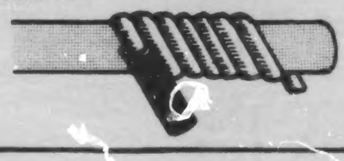
Anchoring

STEP 4



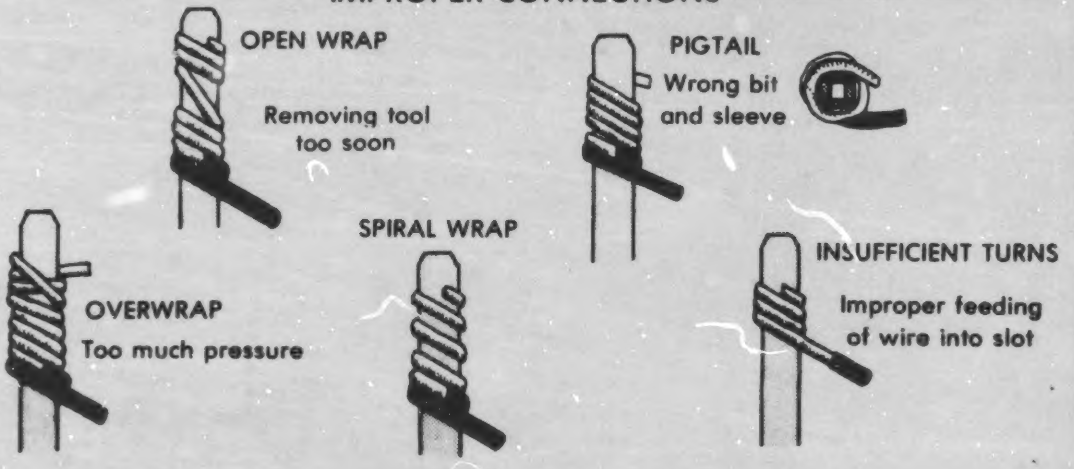
Terminal Insertion

STEP 5



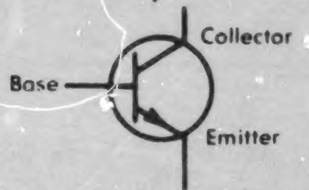
Finished Connection

IMPROPER CONNECTIONS

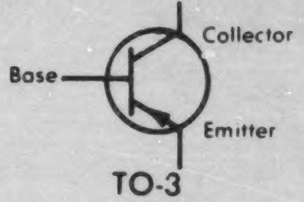

OPEN WRAP
Removing tool too soon
PIGTAIL
Wrong bit and sleeve
SPIRAL WRAP
INSUFFICIENT TURNS
Improper feeding of wire into slot
OVERWRAP
Too much pressure

SEMICONDUCTOR INFORMATION

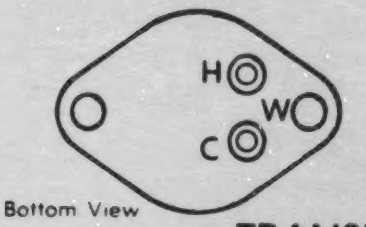
Schematic Symbol - NPN


Collector
Base
Emitter

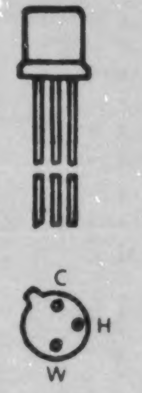
Schematic Symbol - PNP


Collector
Base
Emitter

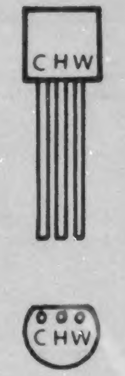
TO-3


H
W
C
Bottom View

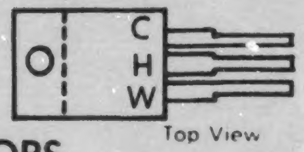
TO-5
TO-18



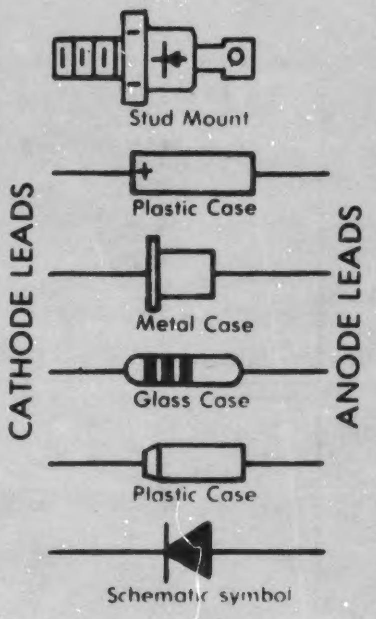
TO-92



TO-220

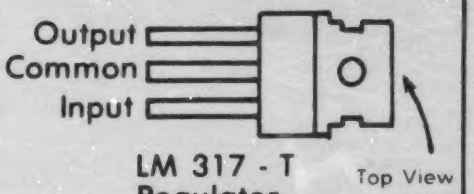

C
H
W
Top View

TRANSISTORS

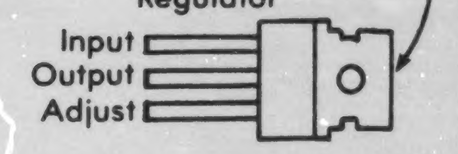

Stud Mount
Plastic Case
Metal Case
Glass Case
Plastic Case
Schematic symbol
CATHODE LEADS
ANODE LEADS

DIODES

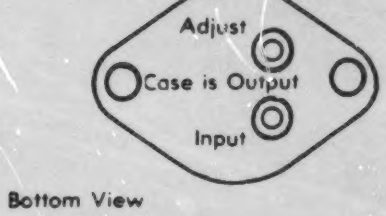
7805 - 5V Regulator


Output
Common
Input
Top View

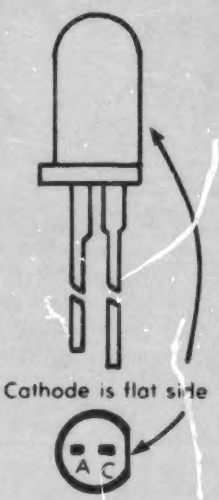
LM 317 - T Regulator

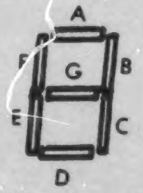

Input
Output
Adjust

LM 317 - K Regulator


Adjust
Case is Output
Input
Bottom View

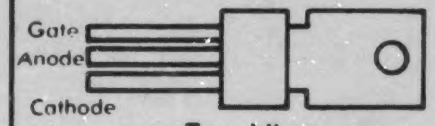
LED


Cathode is flat side
A C



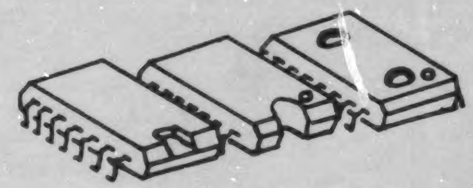
Seven-segment Display

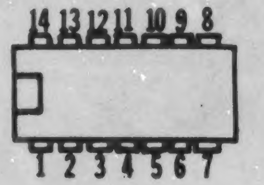
SCR


Gate
Anode
Cathode

Top View

Dip IC Packages




14 13 12 11 10 9 8
1 2 3 4 5 6 7

Top View

LED FLASHER CIRCUIT

II-E-1a(TS)

Name ____________________ **Date** ____________________

Directions: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed to help you understand the instructions. If you have any questions or problems, ask your instructor.

Safety Note:
1. Eye protection MUST be worn when soldering and cutting wire.
2. Soldering irons are HOT and will burn. Be careful!
3. To prevent component damage, check for proper connections.

______ 1. Construct the following circuit on a socketboard using the components in the parts list. Be sure to check your connections. Connect the battery and check for proper operation.

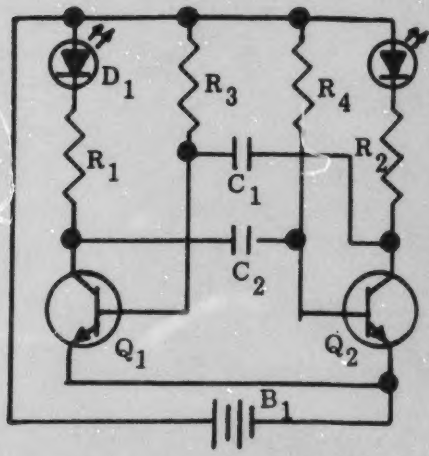
______ 2. Remove the components from the socketboard and straighten the leads.

______ 3. Install the components in their proper location using the component layout as a guide. Be sure to check the transistors, LED's and electrolytic capacitors for proper orientation.

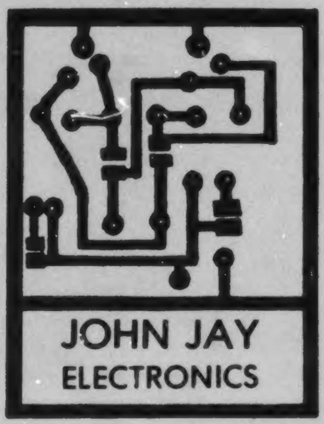
______ 4. Solder the component leads and trim excess length. Be sure to follow the five steps to insure a good solder connection. Remake any unacceptable connections.

______ 5. Fasten the battery to the circuit board using double sided tape. Connect the battery to the battery clip and check the circuit for proper operation.

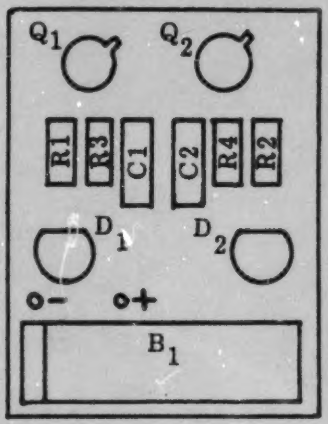
Schematic Diagram:



Board Layout:
(Copper Side)



Board Layout:
(Component Side)



Parts list: R_1-R_2 100 Ohm 1/2W C_1-C_2 10μF @10V D_1-D_2 LED 20 mA Type

R_3-R_4 33K Ohm 1/2W Q_1-Q_2 2N2222 Type B_1 9V with clip

ANTICIPATION TESTER CIRCUIT

II-E-1b (TS)

Name ______________________________ Date ______________________________

Directions: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed to help you understand the instructions. If you have any questions or problems, ask your instructor.

Safety Note:

1. Eye protection MUST be worn when soldering and cutting wire.
2. Soldering irons are HOT and will burn. Be careful!
3. To prevent component damage check for proper connections.

_______ 1. Construct the following circuit on a socketboard using the components in the parts list. Be sure to check your connections.

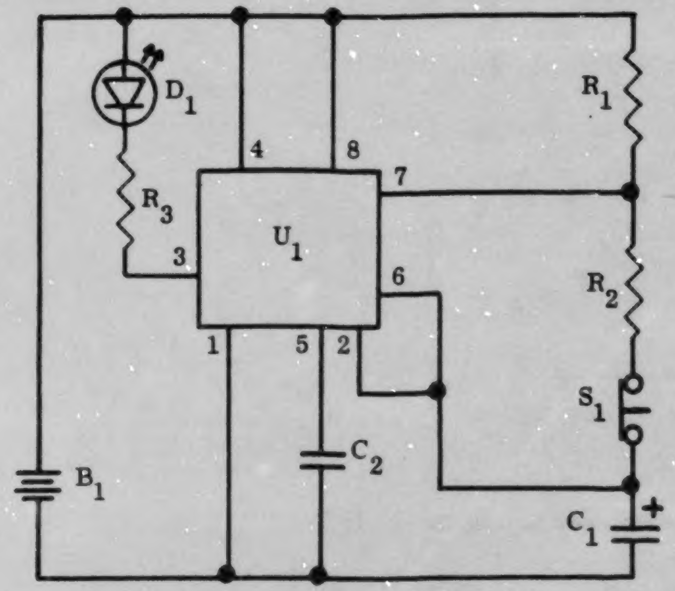
_______ 2. Connect the battery to the battery clip. Check the circuit for proper operation.

_______ 3. Remove the components from the socketboard and straighten the leads.

_______ 4. Using the piece of perforated circuit board, construct the circuit from the schematic diagram. Be sure all components are connected correctly and all solder connections are acceptable.

_______ 5. Fasten the battery to the board using double sided tape. Connect the battery to the battery clip. Check the circuit for proper operation.

Schematic Diagram:



Parts List:

C_1	4.7 μF @ 10V
C_2	.01 μF @ 10V
D_1	LED -- 20 mA Type
U_1	555 Timer IC
R_1	470K Ohm ½ W
R_2	22K Ohm ½ W
R_3	220 Ohm ½ W
S_1	PBNC Switch
B_1	9 Volt Battery

Perforated Board, Battery Clip, 8 Pin Dip IC Socket

CONTINUITY CHECKER CIRCUIT

II-E-1c(TS)

Name ______________________________ Date ______________________________

Directions: Follow the step-by-step instructions. Be sure to have your instructor check your work after each step and indicate successful completion in the space provided. Refer to the example board as needed to help you understand the instructions. If you have any questions or problems, ask your instructor.

Safety Note:

1. Eye protection MUST be worn when soldering, cutting, drilling or handling chemicals.
2. Soldering irons are HOT and will burn. Be careful!
3. To prevent component damage, check for proper connections.

______ 1. Construct the following circuit on a socketboard using the components in the parts list. Be sure to check your connections. Connect the battery and check for proper operation.

______ 2. Remove the components from the socketboard and straighten the leads.

______ 3. Do a pencil layout on graph paper of the circuit. Limit board size to 3" x 4".

______ 4. Do a taped positive artwork of the copper side of the printed circuit board using the pencil layout as a guide.

______ 5. Make a negative from the positive artwork.

______ 6. Print, etch and drill the circuit board.

______ 7. Assemble the circuit board. Be sure components are installed properly. Check for proper operation.

Parts List:

D_1 LED -- 20 mA Type

R_1 4.7K Ohm ½ W

R_2 1K Ohm ½ W

C_1 .1μF @ 16V

C_2 10μF @ 16V

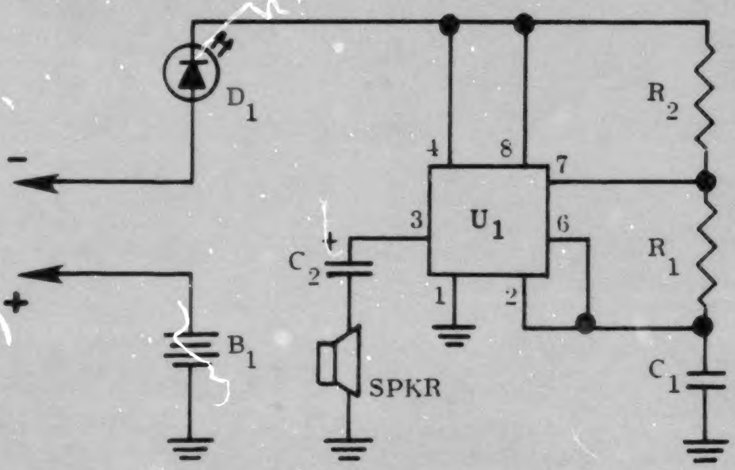
U_1 555 IC

B_1 9 V with Clip

SPKR 8 Ohm -- 1" to 2" Dia.

Set of test leads with clips

Schematic Diagram:



ELECTRICITY

III-A-1a(AS)

Name____________________ Date____________________

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

____________ 1. Matter is anything that occupies space and has ____.

____________ 2. The ____ is the basic unit of any substance.

____________ 3. An atom consists of a nucleus with one or more ____ in orbit.

____________ 4. The nucleus contains one or more ____ and usually one or more neutrons.

____________ 5. An atom with a positive or negative charge is called a/an ____.

____________ 6. Electrons that can move from one atom to another are called ____ electrons.

____________ 7. A material that has many free electrons is called a/an ____.

____________ 8. A material that has few free electrons is called a/an ____.

____________ 9. To provide a path for electric current, ____ are used.

____________ 10. The flow of electrons is called an electric ____.

____________ 11. The excess or deficiency of free electrons on an object is called ____ electricity.

____________ 12. The usual cause of static electricity is ____.

____________ 13. When like charges are brought near each other, they tend to ____ each other.

____________ 14. When unlike charges are brought near each other, they tend to ____ each other.

____________ 15. The unit of measurement for the quantity of electrical charge is the ____.

____________________ 16. Voltage is also called difference of potential, electrical pressure and ____ force.

____________________ 17. The letter symbol for potential difference is ____.

____________________ 18. The unit of measure for potential difference is the ____.

____________________ 19. The unit of measure for current flow is the ____.

____________________ 20. The letter sumbol for current flow is ____.

____________________ 21. By adding ____ electrons to an object, a one coulomb charge is obtained.

____________________ 22. The direction of current flow in a circuit is toward the more ____ terminal of the voltage source.

____________________ 23. A/an ____ is a chemical source of electricity, made up of two dissimilar metal strips placed in an acid solution.

____________________ 24. A/an ____ device is a crystal material such as quartz that generates a voltage when it is subjected to mechanical stress.

____________________ 25. A photovoltaic or ____ converts light energy into electrical energy.

____________________ 26. A/an ____ consists of two different kinds of metals joined at a junction. When heated, a voltage is present across the junction.

____________________ 27. A/an ____ is a machine that converts mechanical energy into electrical energy.

____________________ 28. A dry cell produces approximately ____ volts.

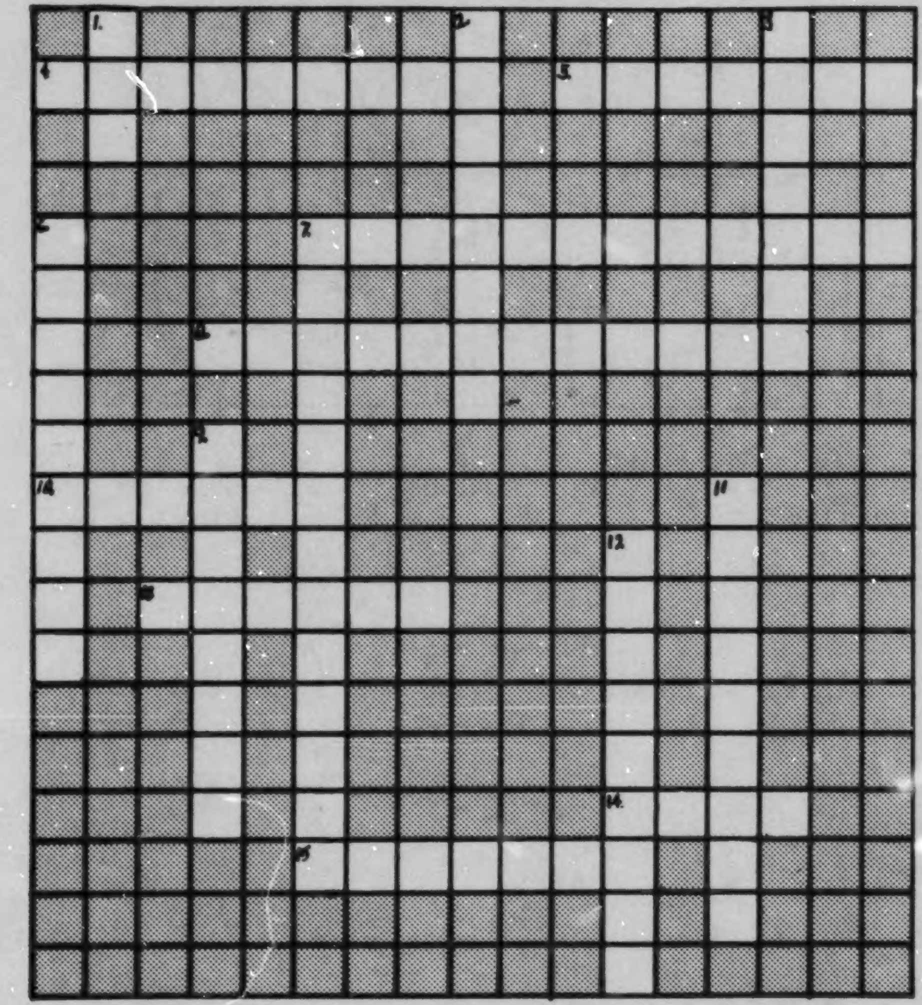
____________________ 29. Voltaic cells are classified as a/an ____ source of electricity.

____________________ 30. For safety, storage batteries must be handled carefully because they contain liquid ____.

ELECTRICITY TERMS

III-A-1b (AS)

Name ____________________________ Date ____________________________



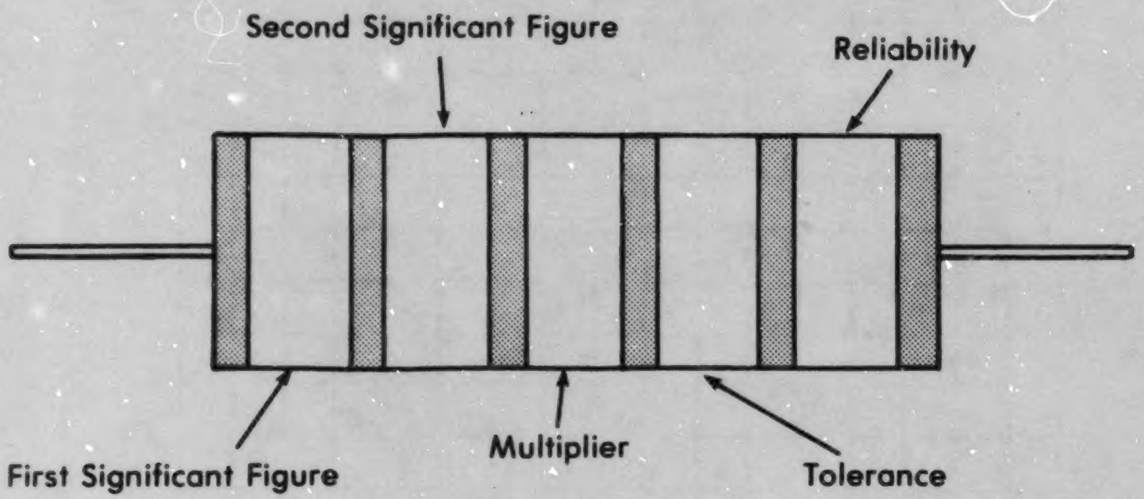
ACROSS CLUES:

4. Many Free Electrons
5. Unit of Electrical Charge
7. Solar Cell
8. Converts Heat to Electrical Energy
10. Unit for Current
13. Careful Handling of Batteries
14. Basic Unit of Any Substance
15. Flow of Electrons

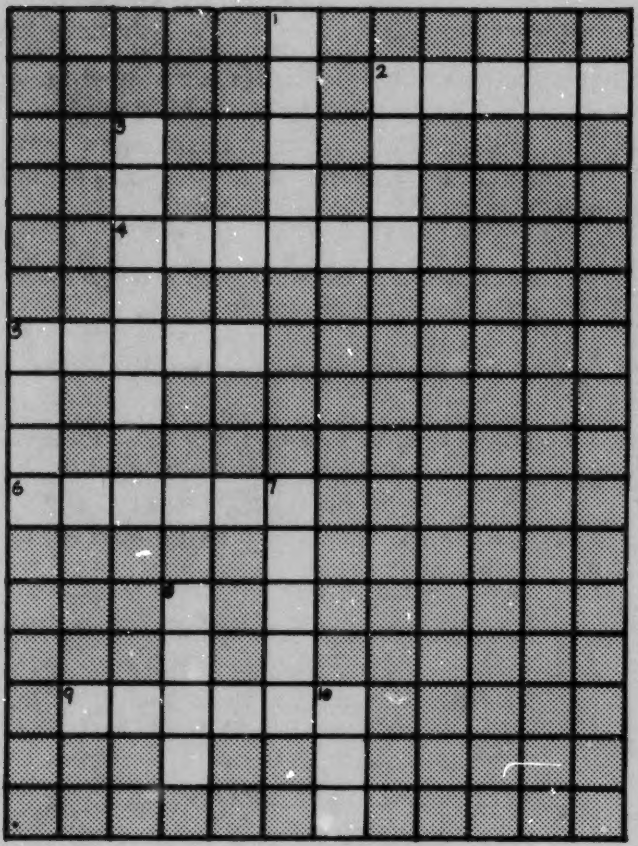
DOWN CLUES:

1. Charged Atom
2. Usual Cause of Static Electricity
3. Potential Difference
6. Converts Mechanical to Electrical Energy
7. Quartz Crystal
9. Current Flows from ___ to Positive
11. Orbit the Nucleus
12. Rubber, Glass, and Mica

ELECTRONIC INDUSTRIES ASSOCIATION RESISTOR COLOR CODE


Second Significant Figure
Reliability
First Significant Figure
Multiplier
Tolerance

Color	Significant Figures	Multiplier	Tolerance	Reliability (per 1,000)
Black	0	$\times 10^{0}$		
Brown	1	$\times 10^{1}$		1%
Red	2	$\times 10^{2}$		0.1%
Orange	3	$\times 10^{3}$		0.01%
Yellow	4	$\times 10^{4}$		0.001%
Green	5	$\times 10^{5}$		
Blue	6	$\times 10^{6}$		
Violet	7	$\times 10^{7}$		
Gray	8	$\times 10^{8}$		
White	9	$\times 10^{9}$		
Gold		$\times 10^{-1}$	5%	
Silver		$\times 10^{-2}$	10%	
None			20%	



ACROSS CLUES:
2. Zero
4. Three
5. Five
6. Four
9. 10%

DOWN CLUES:
1. One
2. Six
3. Seven
5. Eight
7. Nine
8. 5%
10. Two

RESISTANCE

III-B-1b(AS)

Name ______________________________ Date ___________________________

Directions: Each student is to complete this assignment sheet on an individual basis. Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

_____________________ 1. Resistance is the ability of a material to ____ the flow of electric current.

_____________________ 2. The unit of measurement for resistance is the ____.

_____________________ 3. The ability of a material to conduct electricity is called ____.

_____________________ 4. It takes electrical ____ to get current to flow through a resistance.

_____________________ 5. Resistors dissipate energy in the form of ____.

_____________________ 6. Heating elements are constructed using ____ wire because of its high resistance.

_____________________ 7. Most resistors are constructed using powdered ____ or high resistance wire.

_____________________ 8. A variable resistor called a ____ is used to vary voltage in a circuit.

_____________________ 9. A variable resistor called a ____ is used to vary the current flow in a circuit.

_____________________ 10. A/an ____ taper control changes proportionally with the shaft rotation.

_____________________ 11. The ____ size of a resistor determines its power rating.

_____________________ 12. The factors that determine the resistance of a material are the cross-sectional area, length, temperature and the ____ of the material.

_____________________ 13. The larger the gage number of a wire, the ____ resistance it has for a given length.

____________ 14. The first color band on a resistor indicates the ____ of the resistor value.

____________ 15. The second color band on a resistor indicates the ___ of the resistor value.

____________ 16. The third color band on a resistor indicates the ____ of the resistor value.

____________ 17. The fourth color band on a resistor indicates the ____ of the resistor value.

____________ 18. The fifth color band on a resistor indicates the ____ of the resistor value.

____________ 19. A resistor with the color bands gray, white, blue and silver is what value and tolerance?

____________ 20. A resistor with the color bands red, red, orange, and gold is what value and tolerance?

____________ 21. A resistor with the color bands brown, blue, black and silver is what value and tolerance?

____________ 22. A resistor with the color bands green, yellow, gold and silver is what value and tolerance?

____________ 23. A one Kilo Ohm resistor with a 5% tolerance will have an actual value between ____ and ____.

____________ 24. Care must be taken when measuring resistance to be sure there is no ____ present in the circuit.

____________ 25. Be sure to ____ an ohmmeter each time it is used to insure more accurate readings.

RESISTOR COLOR CODE AND MEASUREMENT III-B-1(TS)

Name ______________________ Date ______________________

Directions:
1. Record in the chart below the color of each color band on the numbered resistors.
2. Interpret the color code for the marked value and tolerance and record in the space provided.
3. Calculate the range and record in the space provided.
4. Measure the resistors using the VOM and record the measured value in the space provided.
5. If you have any questions, ask your instructor.

#	1st Color Band	2nd Color Band	3rd Color Band	4th Color Band	Marked Value and Tolerance	Range Low to High	Measured Value
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

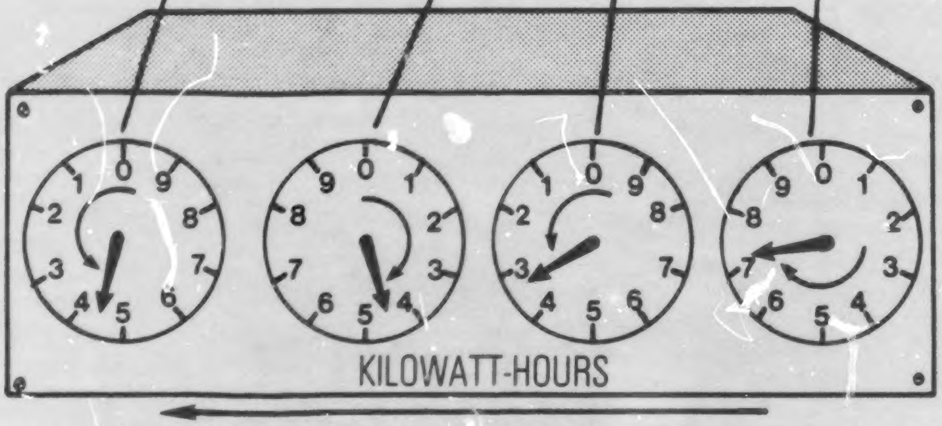
POINTER-REGISTERS ARE READ FROM RIGHT TO LEFT

(A) Record last number passed by pointer - 7

(B) Record last number passed on second dial - 37

(C) Record last number passed on third dial - 437

(D) Record last number passed on fourth dial - 4437



Read from RIGHT to LEFT

OHM'S LAW III-C-1a(AS)

Name ______________________________ Date ________________________

Directions: Use Ohm's Law to complete the statements and solve for unknown values. Round off your answers to three significant figures and write them in the spaces provided using the proper metric prefix. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

____________________ 1. The Ohm's Law formula for voltage is ____.

____________________ 2. If the voltage in a circuit is doubled and the resistance remains the same, the current will ____.

____________________ 3. If the voltage in a circuit remains the same and the resistance is divided in half, the current will ____.

____________________ 4. If the resistance in a circuit doubles and the voltage remains the same, the current will be ____.

____________________ 5. A circuit has 120 V applied across 30 Ohms of resistance; the current will be ____.

____________________ 6. A device that requires 5 A and has a resistance of 10 Ohms must be connected across ____ Volts.

____________________ 7. A device that has a voltage drop of 100 V across it when 4 A of current is flowing through it has a resistance of ____.

____________________ 8. A lamp has a resistance of 40 Ohms and requires 300 mA of current for proper operation. It must be connected to a voltage source of ____.

____________________ 9. A light bulb has a resistance of 110 Ohms. A current of ____ will flow through it when connected to 120 V.

____________________ 10. Calculate the resistance of the filament of a lamp if the current is 0.06 A when applied voltage is 6V.

____________________ 11. I = 2.00 A R = 10.0 Ohms E = ____

____________________ 12. I = 0.20 A R = 250 Ohms E = ____

____________________ 13. I = 3.00 mA R = 25.0 KOhms E = ____

____________________ 14. I = 250 mA R = 3.00 KOhm E = ____

____________ 15. I = 100 mA R = 10 KOhms E = ____

____________ 16. I = 1.00 mA R = 10 MOhms E = ____

____________ 17. I = 2 mA R = 70 Ohms E = ____

____________ 18. E = 20 V R = 10 Ohms I = ____

____________ 19. E = 50 V R = 250 Ohms I = ____

____________ 20. E = 75 V R = 25 Ohms I = ____

____________ 21. E = 10 V R = 10.0 KOhms I = ____

____________ 22. E = 10 V R = 10 MOhms I = ____

____________ 23. E = 75 V R = 3 KOhms I = ____

____________ 24. E = 1.00 V R = 10 KOhms I = ____

____________ 25. E = 10.0 V I = 20 mA R = ____

____________ 26. E = 110 V I = 2.00 A R = ____

____________ 27. E = 10 V I = 1.00 mA R = ____

____________ 28. E = 15 V I = 3.00 mA R = ____

____________ 29. E = 1.00 KV I = 100 mA R = ____

____________ 30. E = 750 V I = 1.00 mA R = ____

____________ 31. E = 1.00 KV I = 10.0 mA R = ____

____________ 32. I = 48.0 uA R = 11.5 KOhm E = ____

____________ 33. E = 25.0 mV I = 35.0 uA R = ____

____________ 34. E = 82.3 V R = 270 Ohms I = ____

____________ 35. I = 12.0 uA R = 12 Ohms E = ____

____________ 36. R = 86 KOhm E = 48 V I = ____

____________ 37. R = 1.2 MOhm E = 24.6 V I = ____

____________ 38. E = 731 V R = 6.8 KOhms I = ____

______ 39. R = 4.7 KOhm E = 600 V I = ___

______ 40. E = 68 mV R = 1.5 KOhm I = ___

______ 41. E = 759 mV R = 2.7 KOhm I = ___

______ 42. I = 393 mA E= 4.14 V R = ___

______ 43. I = 440 mA R = 5.6 KOhm E = ___

______ 44. E = 1.20 mV R = 0.02 Ohm I = ___

______ 45. E = 100 V I = 100 mA R = ___

______ 46. I = 3.00 A R = 45.0 Ohms E = ___

______ 47. E = 10.0 V I = 100 mA R = ___

______ 48. E = 150 V R = 25.0 Ohms I = ___

______ 49. E = 117 V R = 150 Ohms I = ___

______ 50. I = 5.00 mA R = 2.00 MOhm E = ___

OSA 427

POWER FORMULAS

III-C-1b (AS)

Name ______________________________ Date ________________________

Directions: Use the power formulas to solve for the unknown values. Show all work on a work sheet. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

__________________ 1. The formula for power in terms of voltage and current is ____.

__________________ 2. The formula for power in terms of current and resistance is ____.

__________________ 3. The formula for power in terms of voltage and resistance is ____.

__________________ 4. If 0.2 mA of current flows in a circuit with 150 V applied, the power dissipated is ____.

__________________ 5. When 10 V is applied across a 20 Ohm resistor, the power supplied by the source is ____.

__________________ 6. What is the power dissipated by a 25 Ohm lamp that has 632 mA flowing through it?

__________________ 7. A radio uses 190 W from the 120 V power source. The receiver draws ____ of current.

__________________ 8. What is the current through a 1.25 KW electric heater if the resistance is 50 Ohms?

__________________ 9. If the resistance in a circuit remains constant and the current increases, the power will ____.

__________________ 10. If a circuit dissipates 1 W of power when 1 V is applied, the circuit resistance is ____.

__________________ 11. E = 50.0 V   I = 1.00 mA   P = ____

__________________ 12. E = 40.0 V   I = 7.00 mA   P = ____

__________________ 13. E = 60.0 V   I = 4.00 mA   P = ____

__________________ 14. E = 65.0 V   I = 16.0 mA   P = ____

__________ 15. E = 80.0 V I = 2.00 mA P = ____

__________ 16. P = 2.00 W E = 30.0 V I = ____

__________ 17. P = 4.00 mW E = 25.0 V R = ____

__________ 18. R = 5.00 KOhm I = 4.00 ma P = ____

__________ 19. E = 10.0 Volts R = 30.0 KOhms P = ____

__________ 20. P = 8.00 mW I = 40.0 mA R = ____

__________ 21. P = 3.00 Watts I = 27.0 mA E = ____

__________ 22. I = 4.00 mA P = 1.00 Watt E = ____

__________ 23. E = 50 Volts P = 2.20 W I = ____

__________ 24. I = 16.0 mA R = 2.00 KOhms P = ____

__________ 25. E = 45.0 V R = 6.00 KOhms P = ____

__________ 26. E = 20.0 V R = 2.00 Ohms P = ____

__________ 27. P = 240 Watts E = 220 Volts I = ____

__________ 28. R = 90.0 Ohms I = 2.00 A P = ____

__________ 29. I = 12.5 A R = 4.00 Ohms P = ____

__________ 30. P = 125 W E = 50.0 Volts R = ____

__________ 31. E = 67.0 V R = 1.30 MOhms P = ____

__________ 32. I = 71.5 mA R = 1.30 KOhms P = ____

__________ 33. I = 4.08 mA P = 200 mW E = ____

__________ 34. I = 23.3 mA E = 63.0 V P = ____

__________ 35. P = 875 W E = 70.0 V I = ____

__________ 36. I = 3.67 mA P = 161 mW E = ____

__________ 37. E = 35.0 V I = 10.6 mA P = ____

__________ 38. P = 6.02 mW E = 38.0 V R = ____

__________ 39. I = 24.0 A P = 576 W E = ____

__________ 40. R = 4.70 KOhms E = 55.0 V P = ____

__________ 41. I = 6.36 mA P = 8.91 mW R = ____

__________ 42. R = 5.60 MOhms P = 51.6 uW I = ____

__________ 43. R = 10.0 KOhms E = 88.0 V P = ____

__________ 44. I = 8.46 mA R = 1.30 K Ohm P = ____

__________ 45. R = 6.20 KOhms P = 16.1 mW I = ____

__________ 46. E = 86.0 V P = 11.9 W I = ____

__________ 47. E = 72.0 V R = 1.80 MOhms P = ____

__________ 48. P = 24.7 mW I = 573 uA E = ____

__________ 49. R = 270 KOhms P = 28.7 mW I = ____

__________ 50. E = 44.0 V R = 3.00 MOhms P = ____

SERIES RESISTIVE CIRCUITS IV-A-1a(AS)

Name ______________________ Date ________________

Directions: Each student will complete this assignment sheet on an individual basis. Solve the following problems, round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Follow the directions for each section. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

A. Select the word or words which best completes each statement. Place your answer in the space provided. Be sure to check your answers.

____________ 1. The voltage characteristic for a series resistive circuit is ____.

____________ 2. The current characteristic for a series resistive circuit is ____.

____________ 3. The resistive characteristic for a series resistive circuit is ____.

____________ 4. The power characteristic for a series resistive circuit is ____.

____________ 5. Kirchhoff's Voltage Law states that the sum of the voltage drops around a series circuit equals the ____ voltage.

____________ 6. The ____ is always the same at all points in a series circuit.

____________ 7. Resistors connected in series can be used to build ____ values of resistance.

____________ 8. When two resistors are connected in series, there is only one ____ for current through the circuit.

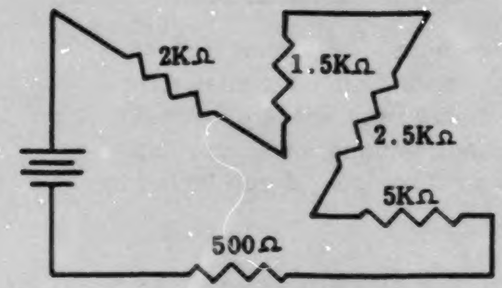
____________ 9. With a 4 Ohm and a 2 Ohm resistor connected in series across a 12 Volt battery, the current through each resistor is ____ Amperes.

____________ 10. In a series circuit, the total resistance is equal to the ____ of the series resistors.

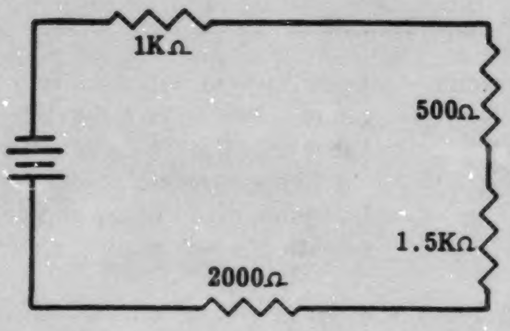
____________ 11. If two equal batteries are connected in series aiding, the voltage across both together will be ____ that of each alone.

____________ 12. If two lamps are connected in series, they must have the same ____ rating.

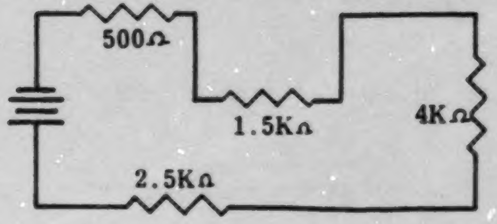
B. Solve for the total resistance in the following circuits. Be sure to check your answers.


2KΩ
1.5KΩ
2.5KΩ
5KΩ
500Ω

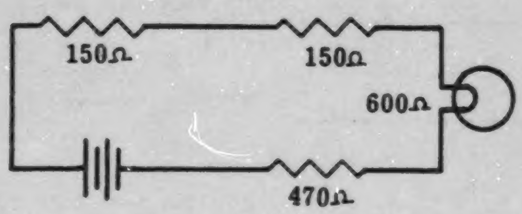
13. ______________


1KΩ
500Ω
1.5KΩ
2000Ω

14. ______________

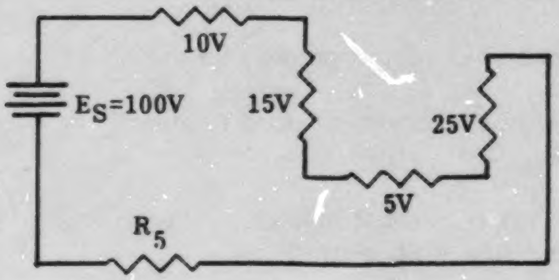

500Ω
1.5KΩ
4KΩ
2.5KΩ

15. ______________

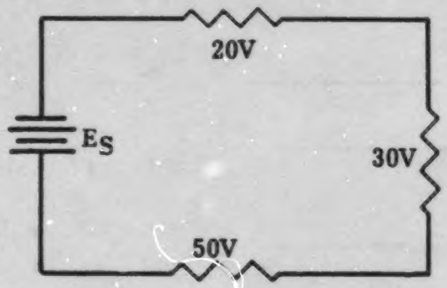

150Ω
150Ω
600Ω
470Ω

16. ______________

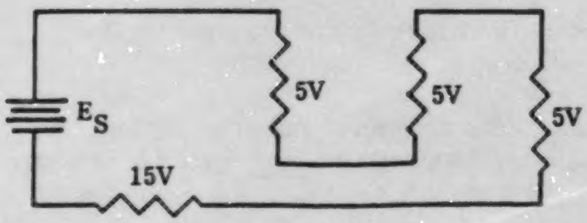
C. Using Kirchhoff's Voltage Law, solve for the indicated voltage value in the following circuits. Be sure to check your answers.


10V
E_S=100V
15V
25V
5V
R_5

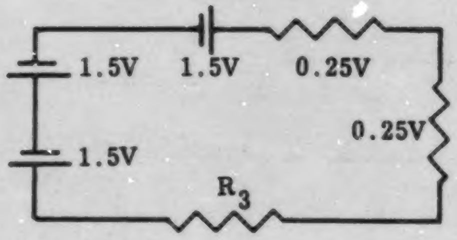
17. E_5 = ______________


20V
E_S
30V
50V

18. E_S = ______________


5V
5V
5V
E_S
15V

19. E_S = ______________


1.5V
1.5V
0.25V
0.25V
1.5V
R_3

20. E_3 = ______________

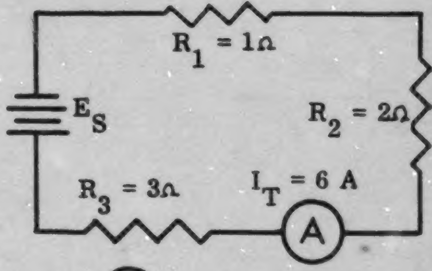
SERIES CIRCUIT ANALYSIS

IV-A-1b (AS)

Name ______________________________ Date ______________________________

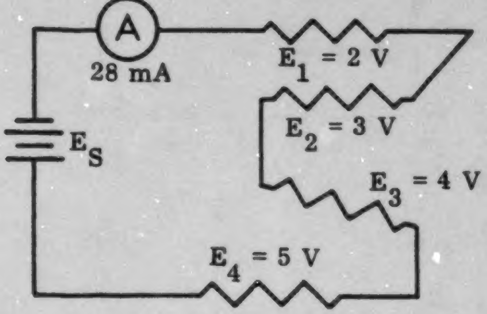
Directions: Each student will complete this assignment sheet on an individual basis. Analyze the following circuits for the values indicated. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

1. E_1 = ____________
2. E_2 = ____________
3. E_3 = ____________
4. E_S = ____________



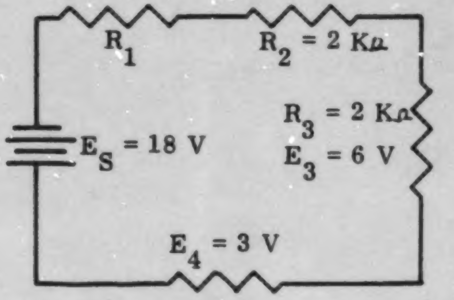
$R_1 = 1\Omega$
E_S
$R_2 = 2\Omega$
$R_3 = 3\Omega$
$I_T = 6$ A
A

5. E_S = ____________
6. R_1 = ____________
7. R_2 = ____________
8. R_3 = ____________
9. R_4 = ____________



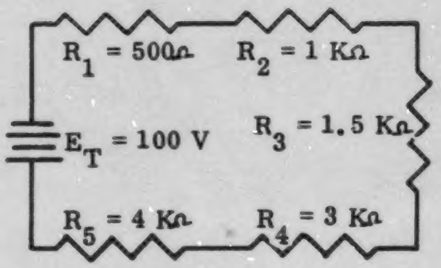
A
28 mA
$E_1 = 2$ V
$E_2 = 3$ V
E_S
$E_3 = 4$ V
$E_4 = 5$ V

10. I_T = ____________
11. E_1 = ____________
12. R_1 = ____________
13. R_4 = ____________
14. R_T = ____________



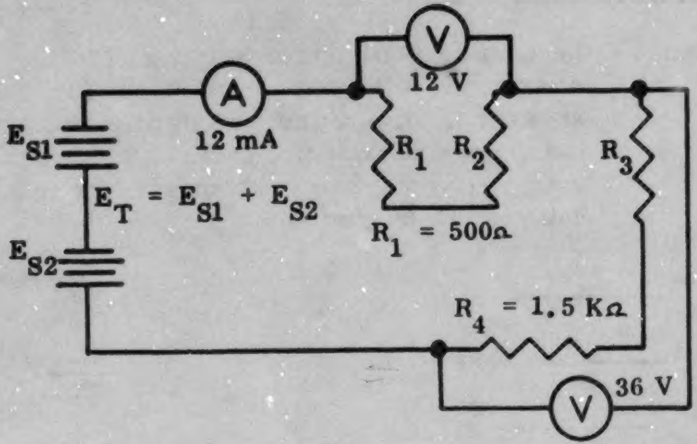
R_1
$R_2 = 2$ KΩ
$R_3 = 2$ KΩ
$E_S = 18$ V
$E_3 = 6$ V
$E_4 = 3$ V

15. I_T = ____________
16. E_1 = ____________
17. E_2 = ____________
18. E_3 = ____________
19. E_4 = ____________
20. E_5 = ____________



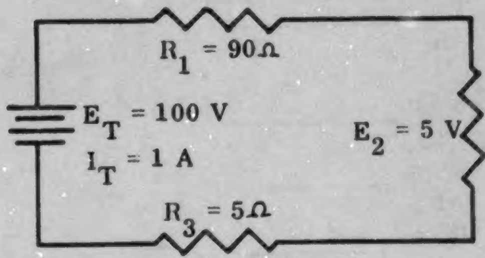
$R_1 = 500\Omega$
$R_2 = 1$ KΩ
$E_T = 100$ V
$R_3 = 1.5$ KΩ
$R_5 = 4$ KΩ
$R_4 = 3$ KΩ

21. R_2 = ________
22. R_3 = ________
23. E_2 = ________
24. E_T = ________
25. R_T = ________
26. P_T = ________


V
12 V
A
12 mA
E_{S1}
$E_T = E_{S1} + E_{S2}$
R_1
R_2
R_3
$R_1 = 500\Omega$
E_{S2}
$R_4 = 1.5\ K\Omega$
V
36 V

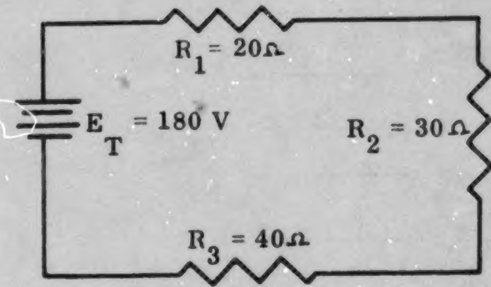
27. R_2 = ________
28. R_T = ________
29. I_3 = ________
30. E_1 = ________

31. E_3 = ________
32. P_1 = ________
33. P_2 = ________
34. P_3 = ________


$R_1 = 90\Omega$
$E_T = 100$ V
$I_T = 1$ A
$E_2 = 5$ V
$R_3 = 5\Omega$

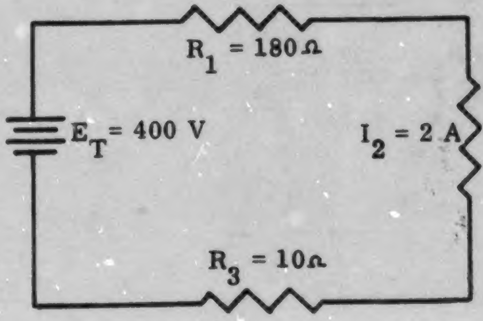
35. R_T = ________
36. I_1 = ________
37. E_1 = ________

38. E_2 = ________
39. E_3 = ________
40. P_2 = ________


$R_1 = 20\Omega$
$E_T = 180$ V
$R_2 = 30\Omega$
$R_3 = 40\Omega$

41. R_T = ________
42. I_T = ________
43. P_T = ________
44. E_1 = ________
45. I_1 = ________

46. R_2 = ________
47. E_2 = ________
48. P_2 = ________
49. E_3 = ________
50. P_3 = ________

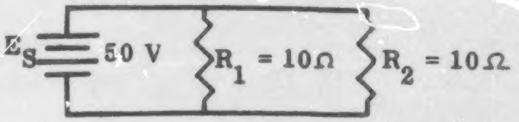

$R_1 = 180\Omega$
$E_T = 400$ V
$I_2 = 2$ A
$R_3 = 10\Omega$

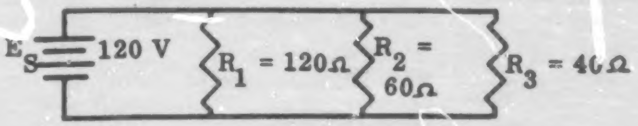
PARALLEL RESISTIVE CIRCUITS IV-B-1(AS)

Name ______________________ Date ______________

Directions: Each student will complete this assignment on an individual basis. Answer questions in the spaces provided. Problem answers should be rounded off to three significant figures and written using the proper metric prefix. Use your class notes and textbook as reference. If you have any questions, ask your instructor.

Find the indicated values for the following circuits.





1. E_1 = ________
2. I_1 = ________
3. E_2 = ________
4. I_2 = ________
5. E_1 = ________
6. E_2 = ________
7. E_3 = ________
8. I_1 = ________
9. I_2 = ________
10. I_3 = ________

__________ 11. With two resistances connected in parallel, the ____ across each resistor must be the same.

__________ 12. With 100 V applied across ten 50 Ohm resistances in parallel, the current through each resistance equals ____.

__________ 13. In a parallel circuit, the ____ appears across each branch.

__________ 14. In a parallel circuit, E_T = ____.

Directions: Find the total resistance for parallel circuits containing the following resistor values.

______ 15. 80Ω , 80Ω and 40Ω

______ 16. 20Ω , 5Ω , 10Ω , and 20Ω

______ 17. 20Ω , 10Ω and 10Ω

______ 18. 10Ω , 20Ω , 20Ω and 10Ω

______ 19. 3 KΩ and 5 KΩ

______ 20. 3Ω , 5Ω , 20Ω and 50Ω

______ 21. 2 KΩ , 4 KΩ , 20 KΩ , 5 KΩ and 10 KΩ

______ 22. 5 MΩ and 20 MΩ

______ 23. 3Ω , 5Ω and 15 KΩ

______ 24. Five 150Ω

______ 25. Seven 150Ω

______ 26. 2 KΩ and 2 KΩ

______ 27. 50Ω and 50Ω

______ 28. 10Ω , 20Ω and 30Ω

____________ 29. In a parallel circuit, the current in each branch is ____ together to determine the total current.

____________ 30. In a parallel circuit, R_T = ____.

____________ 31. In a parallel circuit, I_T = ____.

____________ 32. The ____ is the same across all parts of a parallel circuit.

____________ 33. The total resistance in a parallel circuit is always ____ than the smallest branch resistance.

____________ 34. What resistance must be placed in parallel with 30 ohms to provide a total resistance of 12 ohms?

____________ 35. Two equal resistors in parallel produce an equivalent resistance that is ____ the value of one of the resistors.

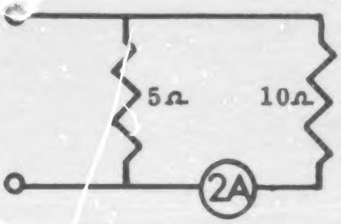
____________ 36. Adding resistors will ____ the total current in a parallel circuit.

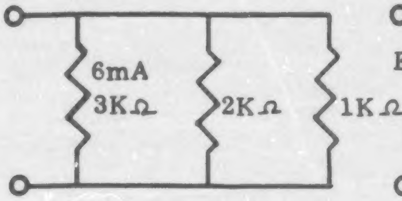
____________ 37. In a parallel circuit, the ____ divides among branches inversely proportional to the branch resistance.

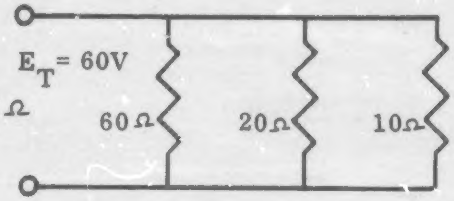
____________ 38. If the total circuit current decreases in a parallel circuit, a/an ____ circuit failure should be suspected.

____________ 39. In a parallel circuit, P_T = ____.

Directions: Solve the following circuits for the indicated unknown values.







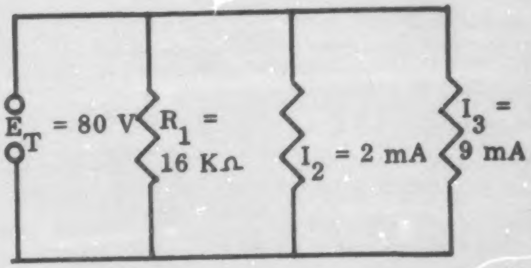
40. E_T = ____________
41. I_T = ____________
42. R_T = ____________

43. R_T = ____________
44. I_T = ____________
45. P_T = ____________

46. I_T = ____________
47. R_T = ____________
48. P_T = ____________

49. R_T = ________
50. I_T = ________
51. P_T = ________
52. I_1 = ________
53. R_2 = ________

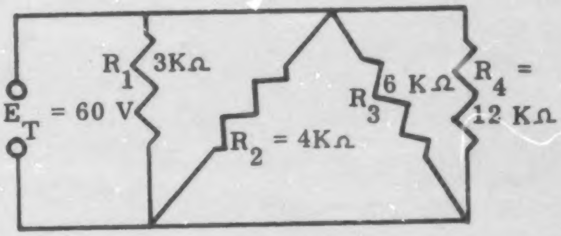
54. R_3 = ________
55. P_1 = ________
56. P_2 = ________
57. P_3 = ________



E_T = 80 V
R_1 = 16 KΩ
I_2 = 2 mA
I_3 = 9 mA

58. R_T = ________
59. I_T = ________
60. I_1 = ________
61. I_2 = ________
62. I_3 = ________

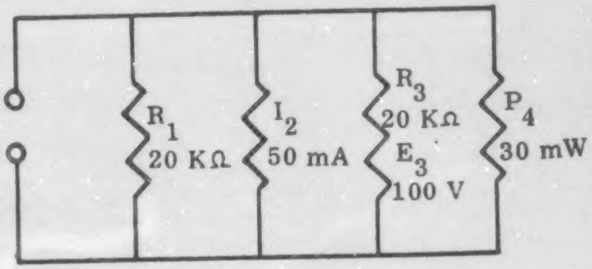
63. I_4 = ________
64. P_T = ________
65. P_1 = ________
66. P_4 = ________



R_1 3KΩ
E_T = 60 V
R_2 = 4KΩ
R_3 6 KΩ
R_4 = 12 KΩ

67. I_T = ________
68. R_T = ________
69. I_1 = ________
70. P_T = ________
71. I_3 = ________
72. I_4 = ________

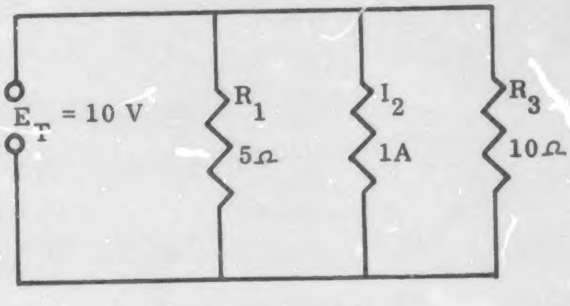
73. R_2 = ________
74. R_4 = ________
75. P_1 = ________
76. P_2 = ________
77. P_3 = ________



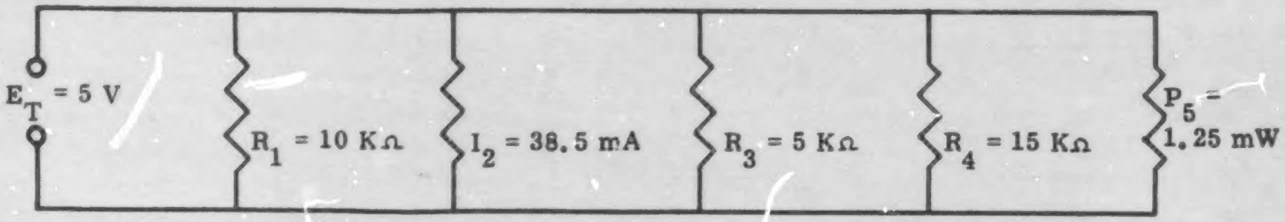
R_1 20 KΩ
I_2 50 mA
R_3 20 KΩ
E_3 100 V
P_4 30 mW

78. R_T = ________
79. P_T = ________
80. I_T = ________
81. R_2 = ________
82. I_1 = ________

83. I_3 = ________
84. P_1 = ________
85. P_2 = ________
86. P_3 = ________



E_T = 10 V
R_1 5Ω
I_2 1A
R_3 10Ω



E_T = 5 V
R_1 = 10 KΩ
I_2 = 38.5 mA
R_3 = 5 KΩ
R_4 = 15 KΩ
P_5 = 1.25 mW

87. R_T = __________

88. I_T = __________

89. P_T = __________

90. I_1 = __________

91. P_1 = __________

92. R_2 = __________

93. P_2 = __________

94. I_3 = __________

95. P_3 = __________

96. I_4 = __________

97. P_4 = __________

98. I_5 = __________

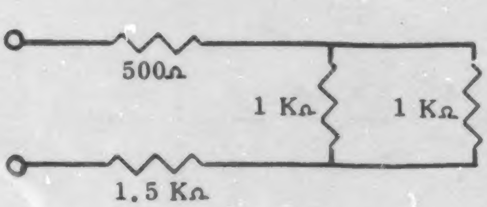
99. R_5 = __________

100. E_5 = __________

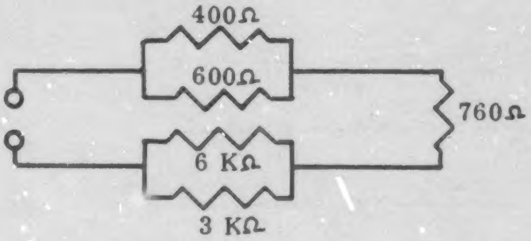
COMPLEX RESISTIVE CIRCUITS IV-C-1(AS)

Name ______________________________ **Date** __________________________

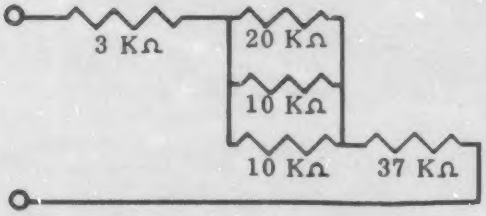
Directions: Each student will complete this assignment sheet on an individual basis. Solve the following circuits for the indicated unknown values. Answer questions in the spaces provided. Problem answers should be rounded off to three significant figures and written in the space provided using the proper metric prefix. Use your class notes and textbook as reference. If you have any questions, ask your instructor.


500Ω
1 KΩ
1 KΩ
1.5 KΩ

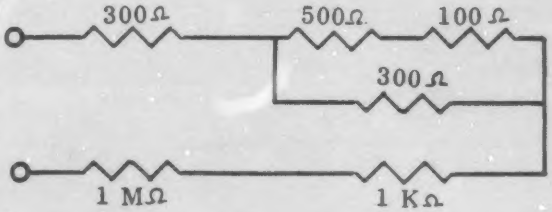
1. R_T = ______________


400Ω
600Ω
760Ω
6 KΩ
3 KΩ

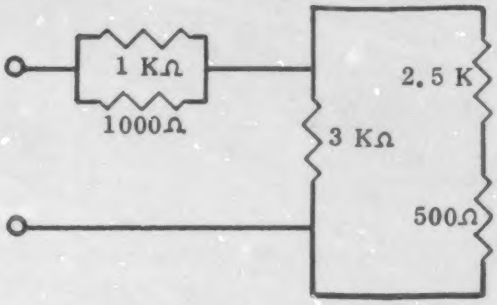
2. R_T = ______________


3 KΩ
20 KΩ
10 KΩ
10 KΩ
37 KΩ

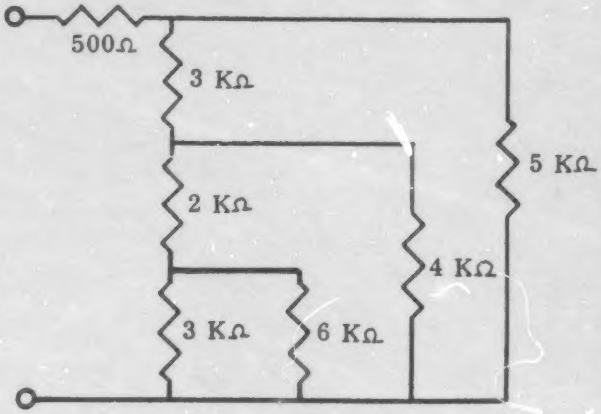
3. R_T = ______________


300Ω
500Ω
100 Ω
300 Ω
1 MΩ
1 KΩ

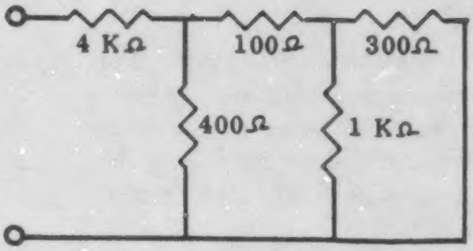
4. R_T = ______________


1 KΩ
1000Ω
2.5 K
3 KΩ
500Ω

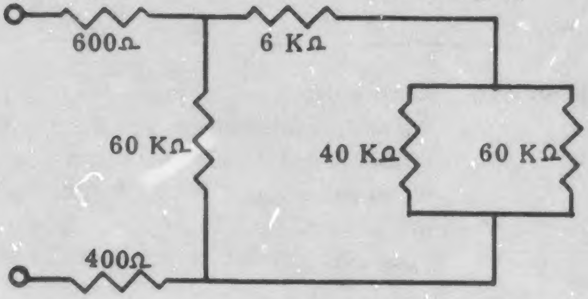
5. R_T = ______________


500Ω
3 KΩ
5 KΩ
2 KΩ
4 KΩ
3 KΩ
6 KΩ

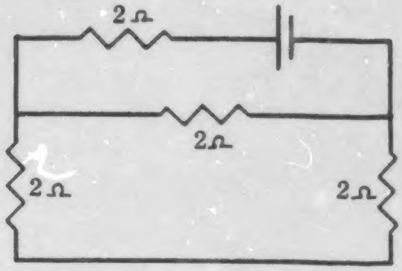
6. R_T = ______________


4 KΩ
100Ω
300Ω
400Ω
1 KΩ

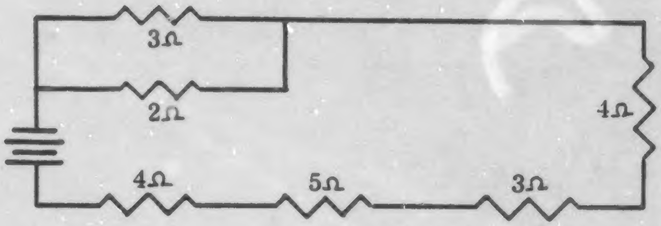
7. R_T = ____________


600Ω
6 KΩ
60 KΩ
40 KΩ
60 KΩ
400Ω

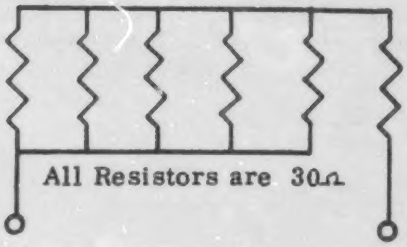
8. R_T = ____________



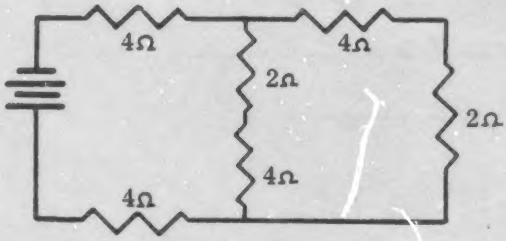
9. R_T = ____________


3Ω
2Ω
4Ω
4Ω
5Ω
3Ω

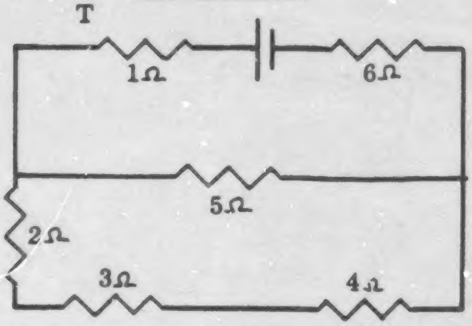
10. R_T = ____________


All Resistors are 30Ω

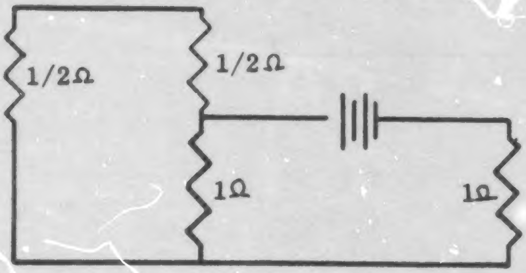
11. R_T = ____________


4Ω
4Ω
2Ω
2Ω
4Ω
4Ω

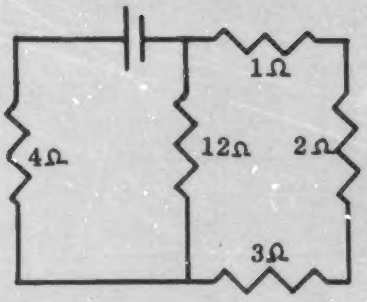
12. R_T = ____________

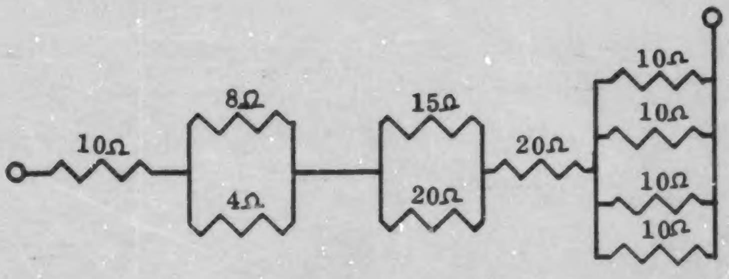

1Ω
6Ω
5Ω
2Ω
3Ω
4Ω

13. R_T = ____________


1/2Ω
1/2Ω
1Ω
1Ω

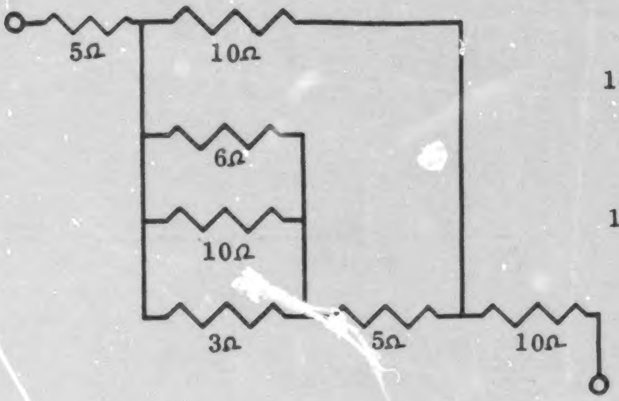
14. R_T = ____________

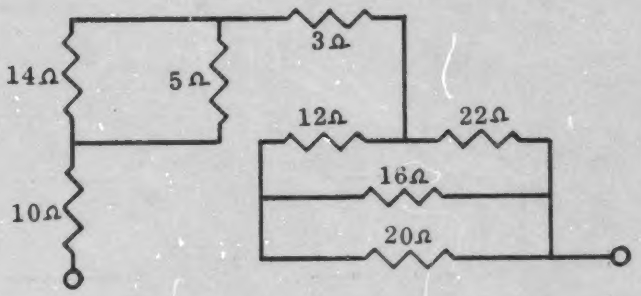

1Ω
4Ω
12Ω
2Ω
3Ω


10Ω
8Ω
4Ω
15Ω
20Ω
20Ω
10Ω
10Ω
10Ω
10Ω

15. R_T = ____________

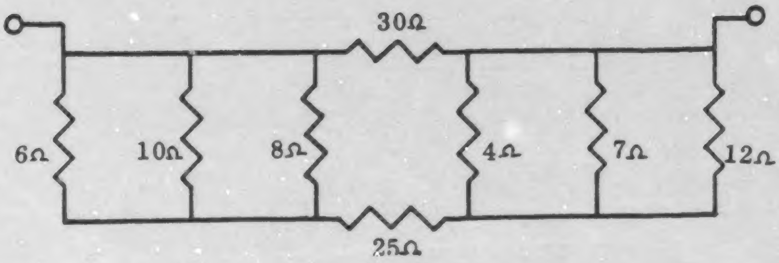
16. R_T = ____________

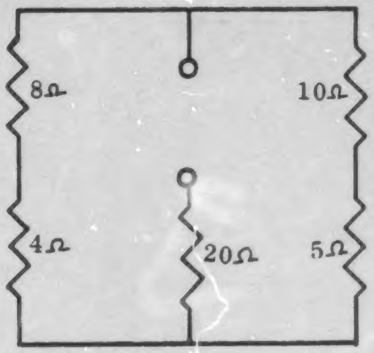

5Ω
10Ω
6Ω
10Ω
3Ω
5Ω
10Ω


14Ω
5Ω
3Ω
12Ω
22Ω
16Ω
10Ω
20Ω

17. R_T = ____________

18. R_T = ____________


30Ω
6Ω
10Ω
8Ω
4Ω
7Ω
12Ω
25Ω


8Ω
10Ω
4Ω
20Ω
5Ω

19. R_T = ____________

20. R_T = ____________

21. R_T = ____________

22. I_T = ____________

23. I_1 = ____________

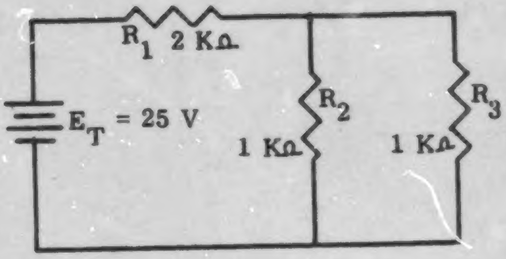
24. I_2 = ____________

25. I_3 = ____________

26. E_1 = ____________

27. E_2 = ____________

28. E_3 = ____________


R_1 2 KΩ
E_T = 25 V
R_2
1 KΩ
R_3
1 KΩ

29. R_T = ____________

30. I_T = ____________

31. E_1 = ____________

32. E_2 = ____________

33. E_3 = ____________

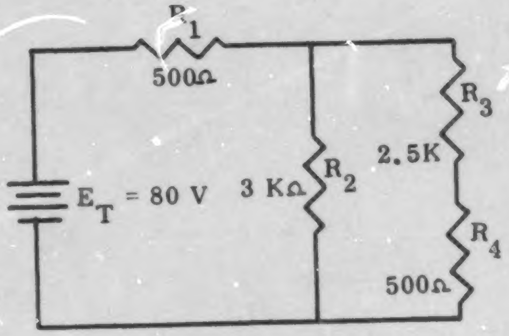
34. E_4 = ____________

35. I_1 = ____________

36. I_2 = ____________

37. I_3 = ____________

38. I_4 = ____________


R_1
500Ω
E_T = 80 V
3 KΩ
R_2
R_3
2.5K
R_4
500Ω

39. R_T = ____________

40. I_T = ____________

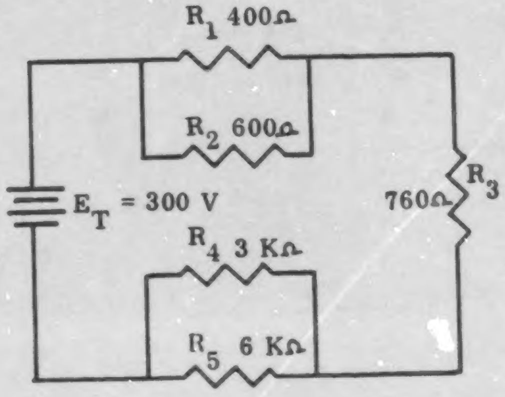
41. E_1 = ____________

42. E_2 = ____________

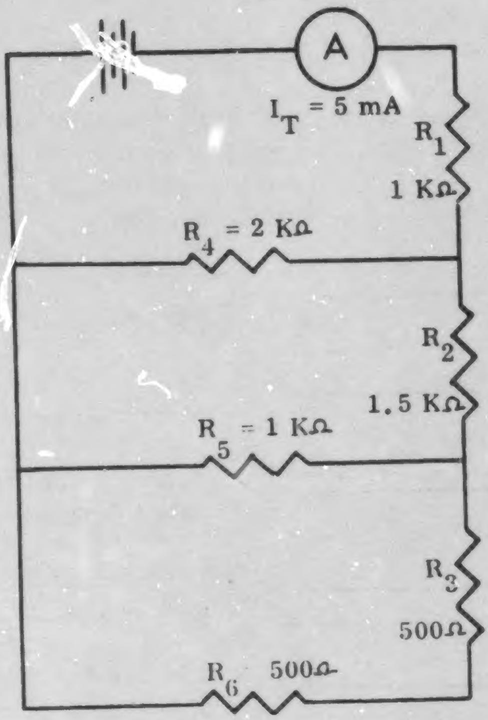
43. E_3 = ____________

44. E_4 = ____________

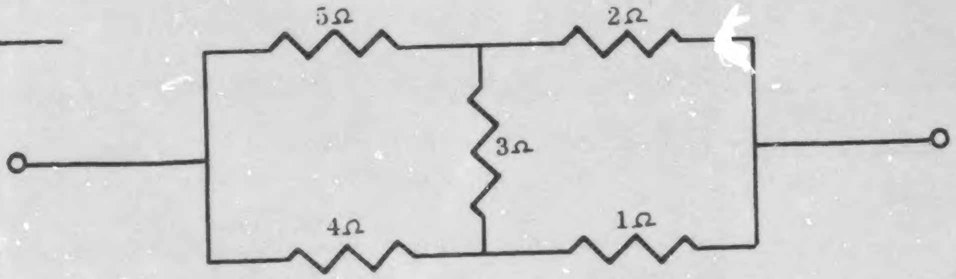
45. E_5 = ____________


R_1 400Ω
R_2 600Ω
E_T = 300 V
760Ω
R_3
R_4 3 KΩ
R_5 6 KΩ

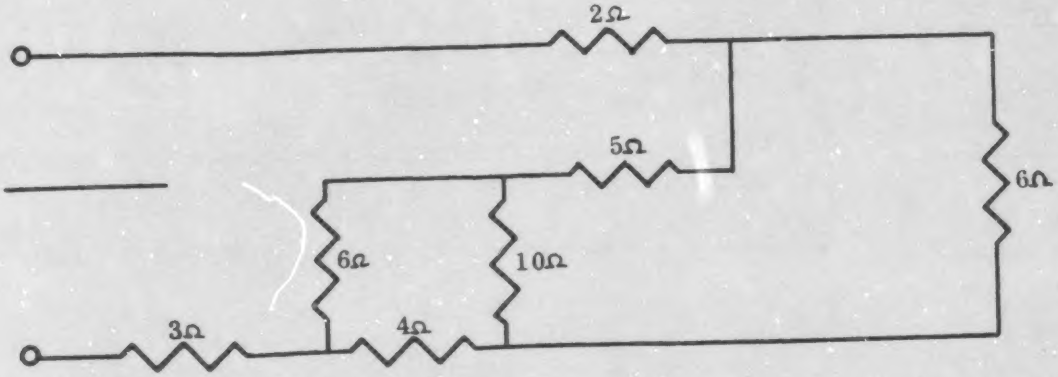
46. R_T = __________
47. E_T = __________
48. I_1 = __________
49. I_2 = __________
50. I_3 = __________
51. I_4 = __________
52. I_5 = __________
53. I_6 = __________
54. E_1 = __________
55. E_2 = __________
56. E_3 = __________
57. E_4 = __________
58. E_5 = __________
59. E_6 = __________
60. P_T = __________
61. P_1 = __________
62. P_2 = __________
63. P_3 = __________
64. P_4 = __________
65. P_5 = __________
66. P_6 = __________


A
I_T = 5 mA
R_1
1 KΩ
R_4 = 2 KΩ
R_2
1.5 KΩ
R_5 = 1 KΩ
R_3
500Ω
R_6 500Ω

67. R_T = __________


5Ω
2Ω
3Ω
4Ω
1Ω

68. R_T = __________


2Ω
5Ω
6Ω
6Ω
10Ω
3Ω
4Ω

D.C. METER CIRCUITS

IV-D-1(AS)

Name ______________________________ Date ________________________

Directions: Read each statement carefully. Select the work or words which best completes each statement and place it in the space provided. Use your textbook and class notes as reference. If you have any questions, ask your instructor.

____________ 1. The ____ meter movement depends on the interaction between permanent and electromagnets.

____________ 2. The ____ of a meter movement can be expressed as the amount of current required for full-scale deflection.

____________ 3. A/an ___ resistance is connected across a meter to extend the range for current measurements.

____________ 4. The sensitivity of a meter movement ___ (can/cannot) be changed.

____________ 5. A meter movement has a sensitivity of 0.05 mA and requires a voltage of 3.75 mV for full-scale deflection. A shunt resistor of ____ is required for a range of 1A.

____________ 6. Calculate the shunt required to convert a meter to read 0 to 50 mA when the meter has a sensitivity of 1 mA and a resistance of 50 Ohms.

____________ 7. A/an ____ resistor is used to expand the range of a voltmeter.

____________ 8. What value of multiplier resistor is needed to convert a 1 mA - 1 V meter movement to read 5 Volts full-scale?

____________ 9. A meter movement requires 100 μA at 1 Volt for full-scale deflection. The meter has a sensitivity of ___ Ohms per Volt.

____________ 10. A 50 μA meter movement has a resistance of 1,000 Ohms. What value of multiplier resistance is needed for a voltmeter range of 10 V?

____________ 11. The ____ indicates resistance by measuring the current flowing through a series circuit.

____________ 12. The ____ in an ohmmeter should be replaced if the meter cannot be zero adjusted.

____________ 13. For safety reasons, an ohmmeter must never be used to measure resistance in a/an ____ circuit.

____________ 14. To conserve batteries, an ohmmeter should not be stored with its probes ____.

____________ 15. A 0-1 mA, 100 Ohm meter movement must have a resistance of ____ and a 1.5 V battery in series with it to be used as a series ohmmeter.

____________ 16. The scale of an ohmmeter is a ____ scale.

____________ 17. An instrument used to accurately measure resistance is the ____ bridge.

____________ 18. A/an ____ is a sensitive current measuring device that will measure current in either direction.

____________ 19. A bridge circuit is balanced when there is ____ current flowing through the measuring device.

____________ 20. A multimeter of VOM accomplishes maximum utilization of a single ____.

MAGNETISM

V-A-1(AS)

Name ______________________________ Date ________________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

____________ 1. Magnetism is an invisible force ____ which exists around a magnet.

____________ 2. The lines of force of a magnetic field are called magnetic ____.

____________ 3. The direction of flux is from the _____ to the ____ pole of a magnet.

____________ 4. The ____ rule is used to determine the direction of flux around a conductor carrying current.

____________ 5. Two parallel conductors will ____ each other if their currents are in the same direction.

____________ 6. A magnetic material containing iron is sometimes called a/an _____ material.

____________ 7. Nonmagnetic materials do not _____ flux from passing through them.

____________ 8. The ____ within a permanent magnet will remain aligned after removal from the magnetizing force.

____________ 9. The effort exerted in creating a magnetic field is called ____ force.

____________ 10. When a core material is _____, increasing the magnetomotive force will not increase the flux.

____________ 11. The flux that remains in a temporary magnet when the magnetizing field is removed is called ____ magnetism.

____________ 12. The opposition within a material to magnetic flux is ____.

____________ 13. The ability of a material to retain magnetism is called ____.

_____________ 14. The basic unit of magnetomotive force is ____.

_____________ 15. The ease with which magnetic flux will pass through a material is ___.

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

_____________ 16. Magnetic flux is assumed to leave a north pole and enter a south pole.

_____________ 17. Magnetic lines of flux are continuous loops.

_____________ 18. Non-magnetic materials have orderly arranged domains.

_____________ 19. Permanent magnet materials have very little residual magnetism.

_____________ 20. Permeability refers to the ability of a material to carry magnetic flux.

ELECTROMAGNETIC DEVICES V-B-1(AS)

Name ______________________ Date ______________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space on the left. Be sure to check your answers. If you have any questions, ask your instructor.

__________ 1. The most common method of producing electricity is by passing a coil through a _____ field.

__________ 2. One factor that controls generated voltage is the ____ of the coil.

__________ 3. Adding more conductors to a coil increases ____ output.

__________ 4. Commutators are used on ____ generators.

__________ 5. Generator brushes are made of _____.

__________ 6. Generators may be either permanenet magnet or ____ coil types.

__________ 7. Electric motor action can be described as a generator in ____.

__________ 8. In permanent magnet motors, repulsion is caused by changes in ____.

__________ 9. Repulsion in permanent magnet motors causes the armature to ____.

__________ 10. In series DC motors the ____ are wired in series.

__________ 11. A ____ DC motor can be started under heavy loads.

__________ 12. An advantage of the ____DC motor is its constant speed.

__________ 13. Motors that run on either AC or DC are termed ______.

__________ 14. Slip rings are used in _____ generators.

__________ 15. Turning or twisting force is termed ___.

__________ 16. Magnetic reed switches are usually of the ___ type.

__________ 17. Speakers convert electrical energy into _____ energy.

__________ 18. Single phase induction motors must have a ____ mechanism.

__________ 19. When energized, a solenoid _____ is moved.

__________ 20. When energized, a DC motor _____ turns.

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

__________ 21. Series DC motors have one path for the current.

__________ 22. The coils of universal motors are wired in series.

__________ 23. The direction of armature rotation is reversed if a universal motor is changed from AC to DC.

__________ 24. The use of relays is limited due to the few switch arrangements available.

__________ 25. Phase splitting is used to start series DC motors.

ALTERNATING CURRENT

In a direct current circuit, the current always flows from the negative terminal of the source, through the load, and back to the positive terminal. This is the distinguishing characteristic of DC; DC is unidirectional with respect to emf and current.

As we have seen in previous introductory discussions, alternating current is characterized by periodic reversals of emf and current. At any given instant, current flow still follows the - to + rule, but as the emf reverses its polarity, so does the current.

The maximum or peak value of an AC voltage or current is the highest value attained during a single cycle, on either a positive or negative alternation. The instantaneous value of voltage or current is the magnitude of the quantity at any given instant. If you are asked to state the instantaneous value of some voltage wave, you must also be told the phase at which this instantaneous voltage is to be read. The average value of a single alternation is 0.637 times the peak value. You should commit to memory the fact that the average or current of a single alternation of sinusoidal (sine wave shape) AC may be found by multiplying the peak value by 0.637 as shown in figure 1.

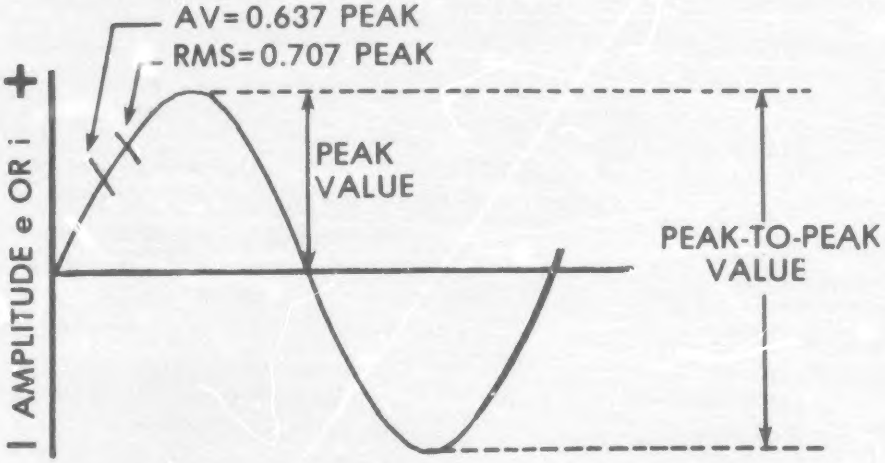


Figure 1

The effective value of voltage or current in AC has an entirely different meaning than the average just discussed. To understand the significance of the effective value of a voltage or current, consider this example: a direct current of 1 Amp; that is, a steady flow of 1 Amp causes a certain conductor to heat to a certain temperature in a fixed period of time. An alternating current of 1 Amp peak value, however, causes only 70.7 per cent as much heat as the direct current of 1 Amp. We say, therefore, that a peak current of any magnitude is only 0.707 times as effective in producing heat as a steady current of the same magnitude. The inability of the AC to produce the same heating effect as DC of the same magnitude as the peak AC is due to the fact that the AC reaches this magnitude for only a relatively short time in each cycle. All the rest of the time, the magnitude is less than peak. On the other hand, DC of a given magnitude is "always up there", so to speak, maintaining the same high value throughout the duty period. Thus, the effective value of any AC current or voltage = 0.707 times the peak value as shown in figure 1.

The maximum value or amplitude of an alternating voltage or current is also called the peak value. The peak value of voltage of an AC wave is the highest voltage that is reached on either the positive or negative alternation. The period of the wave is the time required to complete 1 cycle of the wave, and the wavelength is the distance traveled by the wave in one cycle.

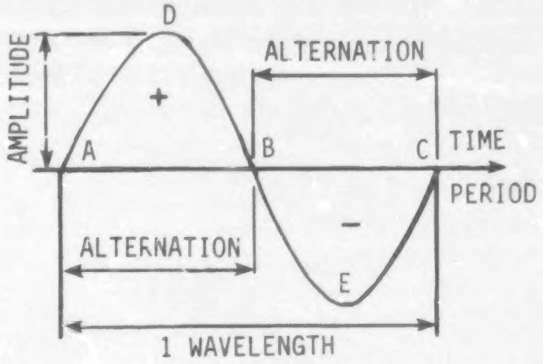


Figure 2

The sine wave with its time axis divided in degrees is shown below in figure 3. The term phase, as referred to any wave, relates to the position of a point on the wave in terms of the markings on the horizontal axis. For example, point A, located on the curve itself, is said to be in the 45° phase because a vertical line dropped through A passes through the 45° marking on the time axis; by the same reasoning, point B on the curve is in the 90° phase. Two waves superimposed on the same axis are said to be in-phase when they attain corresponding amplitudes at the same phases. Thus, the waves in figure 3 are in-phase with each other. When corresponding amplitudes occur at different phases, the waves are then out-of-phase.

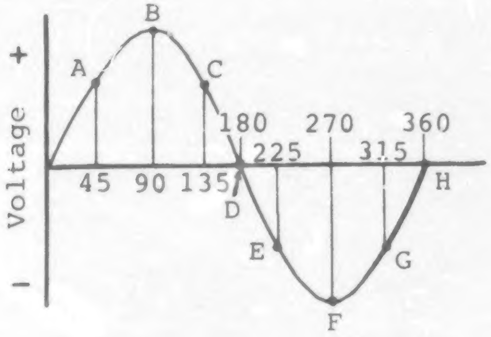


Figure 3

ALTERNATING CURRENT

Name ________________________ Date ________________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

__________ 1. The _____ value of a single alternation of a sine wave is 0.637 times the peak value.

__________ 2. If the peak value of a sine wave is 100 V, the average value is _____.

__________ 3. If the peak value of a sine wave current is 10 A, the average value is ___.

__________ 4. If the peak value of a sine wave voltage is 200 V, the average value of one alternation is ____.

__________ 5. The average value of a complete sine wave cycle is _____.

__________ 6. An AC with a peak value of 10 V causes the same heating effect as a DC of ______.

__________ 7. An AC with a peak value of 100 mA causes the same heating effect as a DC of _____.

__________ 8. An AC with a Peak-to-Peak value of 30 V will have an RMS value of _____.

__________ 9. Alternating currents between about 20 Hz and 20,000 Hz when changed into sound by a speaker are called ____ frequencies.

__________ 10. Alternating currents of frequencies higher than 20 K Hz are called _____ frequencies.

__________ 11. The period of an AC wave having a frequency of 1.20 K Hz is _____.

__________ 12. The formula for the frequency of an AC wave is _____.

__________ 13. An alternation of sine wave AC is ____ electrical degrees.

__________ 14. A cycle of AC is _____ electrical degrees.

__________ 15. The ____ value of AC will produce the same heat in a resistor as an equal value of DC.

__________ 16. The number of cycles per second is called the ____ of the wave.

__________ 17. The amount of time for one cycle is called the ____ of the wave.

__________ 18. The wavelength of a sine wave having a frequency of 15 M Hertz is _____.

__________ 19. The angular difference between two sine waves of the same frequency is called the ____.

__________ 20. The _____ adjusts the clarity of the display on an oscilloscope.

__________ 21. The _____ control is used to control the time base sweep rate on the oscilloscope.

__________ 22. The _____ control is used to control the amplitude portion of the oscilloscope display.

__________ 23. The _____ provides the visual display of the waveforms on an oscilloscope.

__________ 24. For the clearest presentation on an oscilloscope, _____ cycles of input wave should be displayed.

__________ 25. A/an ____ display on an oscilloscope can be used to determine the phase relationship between two waves.

OSCILLOSCOPE

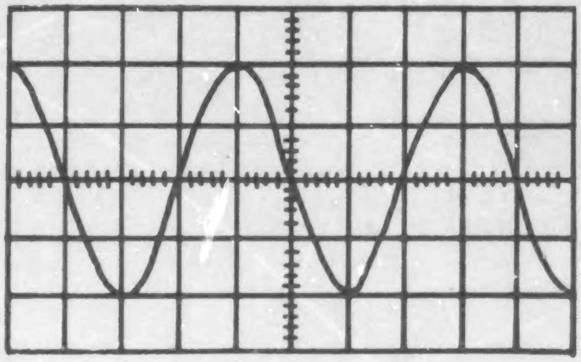
VI-A-1(TS)

Name ______________________ Date ______________________

Directions: Using the oscilloscope display and the settings indicated for each set of questions, determine the values for each wave. Place your answers in the space provided. If you have any questions, ask your instructor.

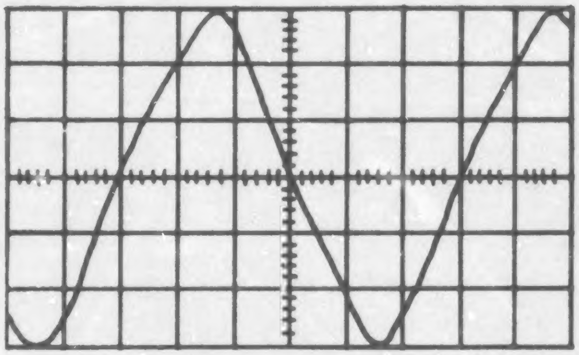
VERTICAL at .1 Volt/cm
HORIZONTAL at 5 m Sec/cm

1. Peak Voltage __________
2. Pk-Pk Voltage __________
3. RMS Voltage __________
4. Period __________
5. Frequency __________



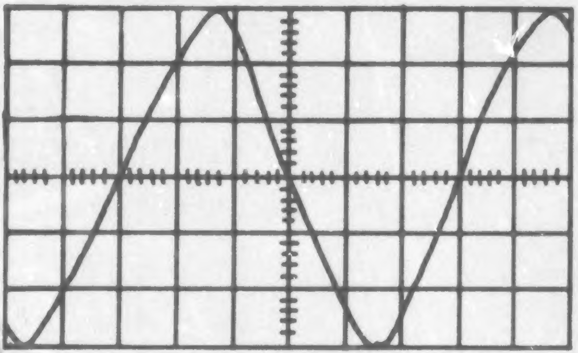
VERTICAL at .5 Volt/cm
HORIZONTAL at 10 m Sec/cm

6. Peak Voltage __________
7. Pk-Pk Voltage __________
8. RMS Voltage __________
9. Period __________
10. Frequency __________



VERTICAL at .02 Volt/cm
HORIZONTAL at 2 μSec/cm

11. Peak Voltage __________
12. Pk-Pk Voltage __________
13. RMS Voltage __________
14. Period __________
15. Frequency __________



VERTICAL at .2 Volt/cm
HORIZONTAL at .1 Sec/cm

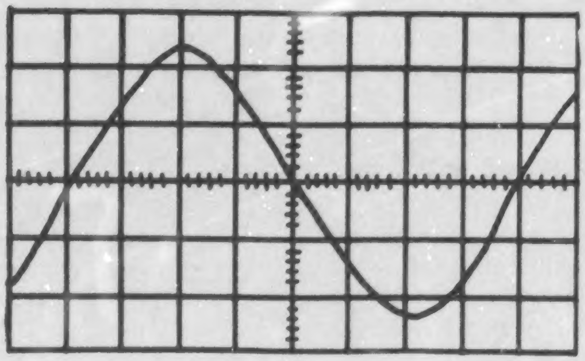
16. Peak Voltage ________

17. Pk-Pk Voltage ________

18. RMS Voltage ________

19. Period ________

20. Frequency ________



VERTICAL at 1 m Volt/cm
HORIZONTAL at 10 μSec/cm

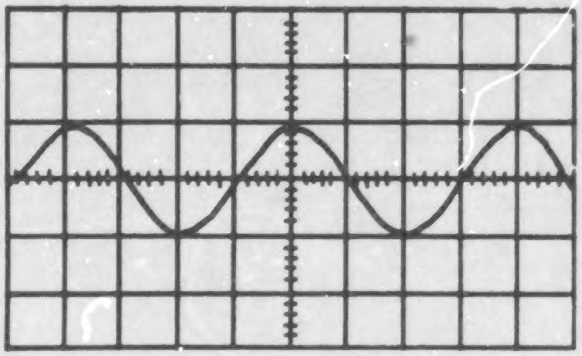
21. Peak Voltage ________

22. Pk-Pk Voltage ________

23. RMS Voltage ________

24. Period ________

25. Frequency ________



VERTICAL at 50 m Volts/cm
HORIZONTAL at 1 m Sec/cm

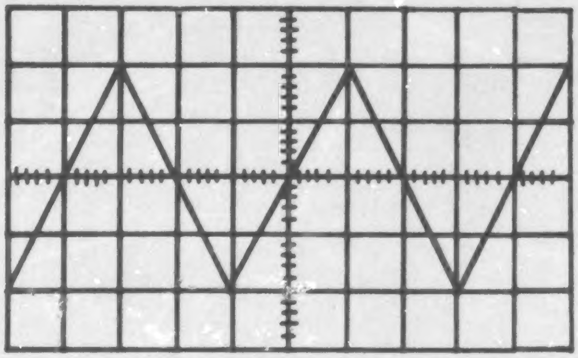
26. Peak Voltage ________

27. Pk-Pk Voltage ________

28. RMS Voltage ________

29. Period ________

30. Frequency ________



Directions: With your lab partner, set up an oscilloscope and signal generator. Take turns setting the generator at various levels and frequencies and operating the scope. If you have any problems or questions, ask your instructor.

INSTRUCTOR CHECK ________

INDUCTANCE

VI-B-1(AS)

Name ______________________________ Date ________________________

Directions: Read each statement carefully. Write the word or words which best completes the statements in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

____________ 1. For induction to take place, _____ must take place between the flux and the conductor.

____________ 2. The current in an inductor changes at the rate of 50 mA in 10 μ Second. The rate of current change is _____.

____________ 3. The inductance of a coil that induces 40 V when its current changes at the rate of 4 A per second is _____.

____________ 4. Area of each turn, number of turns, length of the coil and ____ of the core are physical characteristics of a solenoid that affect its inductance.

____________ 5. The self-induced voltage across a 4 Henry inductance produced by a current change of 12 Ampere per second is _____.

____________ 6. _____ Law states that any voltage generated by induction will oppose the motion producing it.

____________ 7. The inductance of a coil that produces a self induced voltage of 50 mV when the current varies at the rate of 25 mA/sec is ____.

____________ 8. The ability of one conductor to induce a voltage in another is called _____ inductance.

____________ 9. The fraction of the total flux from one coil linking another is called _____.

____________ 10. A high value of k indicated _____ coupling.

____________ 11. Two coils on a common iron core have a k equal to _____.

____________ 12. If two 400 mH coils have a k equal to 0.200, then L_M will equal _____.

____________ 13. Without L_M, the L_T of 10 mH and a 15 mH coil connected in series would be _____.

__________ 14. The inductance of any wiring not involved in a conventional coil is considered _____ inductance.

__________ 15. A 2 μH coil is connected in series aiding with a 6 μH coil. The total inductance is 12 μH. What is the coupling coefficient?

__________ 16. The amount of voltage step-up or step-down in a transformer is determined by its ____.

__________ 17. The side of a transformer connected to the power source is called the _____.

__________ 18. The side of a transformer connected to the load is called the ____.

__________ 19. When the secondary has more turns than the primary, the transformer is a step _____ transformer.

__________ 20. A power transformer has 100 turns for L_p and 5 turns for L_s.

The source voltage is _____ when the load voltage is 6 VAC.

__________ 21. With _____ losses in a transformer, the primary power will equal the secondary power.

__________ 22. The ____ ratio of a transformer is the inverse of the turns ratio.

__________ 23. A transformer with a 6 to 1 voltage step-up ratio has 720 VAC across a 7.2 k Ohm load. The secondary current is ____.

__________ 24. A transformer that has no isolation between the primary and the secondary is a/an _____.

__________ 25. Transformer losses due to induced voltage into the core material is called _____ losses.

__________ 26. To reduce losses in power transformers, _____ is used for the core.

__________ 27. At high frequencies, a ceramic material called _____ is used for core material.

__________ 28. A transformer having a 24 V output and loaded with a 48 Ohm resistor will have ____ of primary current when connected to 240 VAC.

__________ 29. The current in the primary of a transformer is zero, the problem indicated is ______.

__________ 30. When the primary current is less than normal, the problem indicated is _____.

__________ 31. Inductive reactance is _____ to AC current flow.

__________ 32. The inductive reactance of an inductor with steady DC through it is _____ Ohms.

__________ 33. The greater the frequency of the AC flowing through an inductor, the _____ the X_L.

__________ 34. Calculate the total inductive reactance of three coils connected in series, all having an X_L of 25 Ohms.

__________ 35. Calculate the total inductive reactance of three coils in parallel, all having an X_L of 25 Ohms.

__________ 36. In pure inductor, the current _____ the voltage by 90°.

__________ 37. At what frequency will a 10μH coil have 1 K ohm of inductive reactance?

__________ 38. At what frequency will a 10 mH coil have 157 ohms of inductive reactance?

__________ 39. Find the inductive reactance of a coil that has 10 mA flowing through it with 75 V dropped across it.

__________ 40. What size inductor would have a reactance of 100 K Ohms at 60 Hz?

__________ 41. How much inductive reactance will a 6 mH coil have at 41.67 K Hz?

__________ 42. What value inductor will have 15 K Ohms of X_L at 10 M Hz?

__________ 43. If 200 mA peak-to-peak is flowing through an inductive reactance of 150 Ohms, the voltage across it will be ____ RMS.

__________ 44. What value inductor will have a reactance of 500 Ohms at 500 Hz?

__________ 45. How much reactance will a 320 mH inductor have at 600 Hz?

CAPACITANCE

VI-C-1(AS)

Name ______________________________ Date ___________________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers. If you have any questions, ask your instructor.

____________ 1. A capacitor stores energy between its plates in the form of a/an ____.

____________ 2. Air, mica and paper are _____ materials used to separate the plates of capacitors.

____________ 3. A device consisting of two conductors separated by an insulating material is a/an ____.

____________ 4. Making the plate area of a capacitor larger will ______ the capacitance.

____________ 5. The largest capacitance can be obtained by placing two capacitors in _____.

____________ 6. For your safety, capacitors should be _____ before working on circuits.

____________ 7. The band marking on a paper capacitor indicates the lead connected to the _____.

____________ 8. The maximum voltage that can be safely applied across a capacitor is the _____.

____________ 9. Two capacitors can be placed in _____ to increase the WVDC.

____________ 10. Three 30 uF capacitors connected in series would have a total capacitance of _____.

____________ 11. Three 30 uF capacitors connected in parallel would have a total capacitance of _____.

____________ 12. A capacitor opposes a change in ____ in a circuit.

____________ 13. A/an _____ capacitor is polarity sensitive.

____________ 14. The formula for capacitance in electrical terms is _____.

____________ 15. In an electrolytic capacitor, the _____ is a very thin layer of aluminum oxide.

__________ 16. The formula for finding the time constant of a resistor and capacitor in series is _____.

__________ 17. A capacitor will charge to _____ percent of the applied voltage in one time constant.

__________ 18. A 1.0 uF capacitor is charging through a 200 K Ohm resistor from a 10 V source. The time constant is _____.

__________ 19. After one time constant, the capacitor in question #18 will be charged to _____.

__________ 20. For all practical purposes, a capacitor will be fully charged after _____ time constants.

__________ 21. A 1 pF capacitor and a 100 K Ohm resistor have a time constant of _____.

__________ 22. A 0.1 μF capacitor and a 10.5 K Ohm resistor have a time constant of _____.

__________ 23. Capacitive reactance acts as an _____ to AC.

__________ 24. The voltage _____ the current in a pure capacitor by 90°.

__________ 25. If three 100 Ohm capacitive reactances are in series, the total X_C will be _____.

__________ 26. If three 100 Ohm capacitive reactances are in parallel, the total X_C will be _____.

__________ 27. A capacitor has _____ reactance at lower frequencies.

__________ 28. Capacitive reactance is _____ proportional to capacitance.

__________ 29. What is the capacitive reactance of a 0.016 uF capacitor at a frequency of 100 K Hz?

__________ 30. A 0.01 μF capacitor is connected across a 10 V, 60 Hz source. The X_C is _____.

__________ 31. A capacitor across a 120 V, 60 Hz source allows 400 mA of current. The X_C is _____.

__________ 32. What is the value of the capacitor in question # 31?

__________ 33. What size capacitor is needed to have a reactance of 3.77 K Ohms at 100 K Hz?

TEST SECTION

SAFETY TEST

Name ____________________ Date ____________________

DIRECTIONS: List the ten general safety rules that must be followed in this shop at all times.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

DIRECTIONS: List the three primary factors that determine how severe an electrical shock will be.

11. ____________________
12. ____________________
13. ____________________

DIRECTIONS: Write a brief statement explaining why you feel the shop safety rules must be followed by every person in this shop.

____

____

____

____

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____

____

MATHEMATICS TEST

I-C-1(T)

Name ______________________ Date ____________________

DIRECTIONS: Perform the following operations using scientific notation. Round off your answers to three significant figures. Write your answers in the spaces provided as a number between 1 and 10 times ten to a power. Be sure to check your answers. You may use a calculator if you have one.

______________ 1. $(1.65 \times 10^{3}) + (2.54 \times 10^{3}) =$

______________ 2. $(3.24 \times 10^{3}) + (4.65 \times 10^{2}) =$

______________ 3. $(3.78 \times 10^{-1}) - (4.56 \times 10^{-3}) =$

______________ 4. $(5.67 \times 10^{7}) - (45.6 \times 10^{6}) =$

______________ 5. $(6.78 \times 10^{5}) - (432{,}000) + (23.7 \times 10^{4}) =$

______________ 6. $1{,}000 \times 0.000001 \times 10^{6} =$

______________ 7. $0.0005 \times 96{,}000 =$

______________ 8. $0.0000387 \times 10^{-5} \times 0.076 \times 10^{6} \times 81{,}000{,}000 =$

______________ 9. $896{,}100 / 7{,}856 =$

______________ 10. $0.0002538 / 6.845 =$

______________ 11. $14{,}025{,}320 \times 10^{-12} / 0.0000030027 \times 10^{-6} =$

______________ 12. $\sqrt{456 \times 10^{13}} =$

______________ 13. $\sqrt{25.0 \times 10^{3}} =$

______________ 14. 75.5% of 256 =

______________ 15. 5.5% of 1,975 =

______________ 16. $\dfrac{156{,}000 \times 10^{4} \times 704 \times 10^{-6} \times 485{,}000 \times 10^{3}}{573 \times 10^{-8} \times 6.28 \times 10^{12} \times 356{,}178 \times 10^{-2}} =$

______________ 17. $\dfrac{0.432 \times 8{,}350{,}000 \times 10^{-3} \times 5.632 \times 10^{3}}{943{,}000 \times 10^{0} \times 6.28 \times 10^{12} \times 0.000000530 \times 10^{-5}} =$

DIRECTIONS: Write the following using the most suitable metric prefix.

__________ 18. 3,300 Ohms

__________ 19. 55,000,000 Volts

__________ 20. 0.0000005 Henry

__________ 21. 6,000,000,000 Hertz

__________ 22. 0.025 Watt

__________ 23. 56,000 Hertz

__________ 24. 0.000000000002 Farad

__________ 25. 0.000000003 Second

TEST

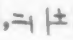
II-A-1(T)

Name ______________________________ Date __________________________

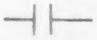
DIRECTIONS: Read each statement carefully. Place the proper symbol or word which best completes the statement in the space provided. Be sure to check your answers.

__________________ 1. The graphic symbol for a fixed resistor is _____.

__________________ 2. The graphic symbol for a fuse is _____.

__________________ 3. The component name for this symbol,  is _____.

__________________ 4. The graphic symbol for an ammeter is ______.

__________________ 5. The component name for this symbol,  is ______.

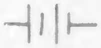
__________________ 6. The graphic symbol for an ohmmeter is _____.

__________________ 7. The graphic symbol for a lamp is _____.

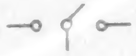
__________________ 8. The graphic symbol for a switch, PBNC is ______.

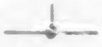
__________________ 9. The graphic symbol for a voltmeter is _____.

__________________10. The graphic symbol for a potentiometer is ______.

__________________11. The letter symbol for this component,  is _____.

__________________12. The letter symbol for an air core coil is _____.

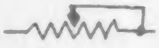
__________________13. The component name for this symbol,  is _____.

__________________14. The component name for this symbol,  is _____.

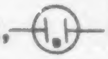
__________________15. The graphic symbol for a switch, DPST is ________.

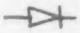
__________________16. The letter symbol for a transistor is ______.

__________________17. The letter symbol for a potentiometer is _______.

__________________18. The component name for this symbol,  is _____.

__________________19. The graphic symbol for a switch, DPDT is _____.

____________________ 20. The component name for this symbol,  is _____.

____________________ 21. The letter symbol for this component,  is _____.

____________________ 22. The graphic symbol for a fixed capacitor is _____.

____________________ 23. The graphic symbol for an adjustable coil is _____.

____________________ 24. The letter symbol for a cell is _____.

____________________ 25. The letter symbol for a diode is _______.

TEST
ON
METER MEASUREMENTS

II-B-1(T)

Name ______________________________ Date _________________________

DIRECTIONS: Read each statment carefully. Place the word or words which best completes the statement in the space provided. Be sure to check your answers.

____________________ 1. A voltmeter is always connected in ________ with the circuit being measured.

____________________ 2. An ammeter is always connected in _______ with the circuit being measured.

____________________ 3. Always set a meter to the highest _______ setting before measuring an unknown voltage or current.

____________________ 4. Always be sure to connect a meter in the circuit with the correct ______ so the meter will not be damaged.

____________________ 5. A/an _____ meter requires time to warm-up before using to make measurements.

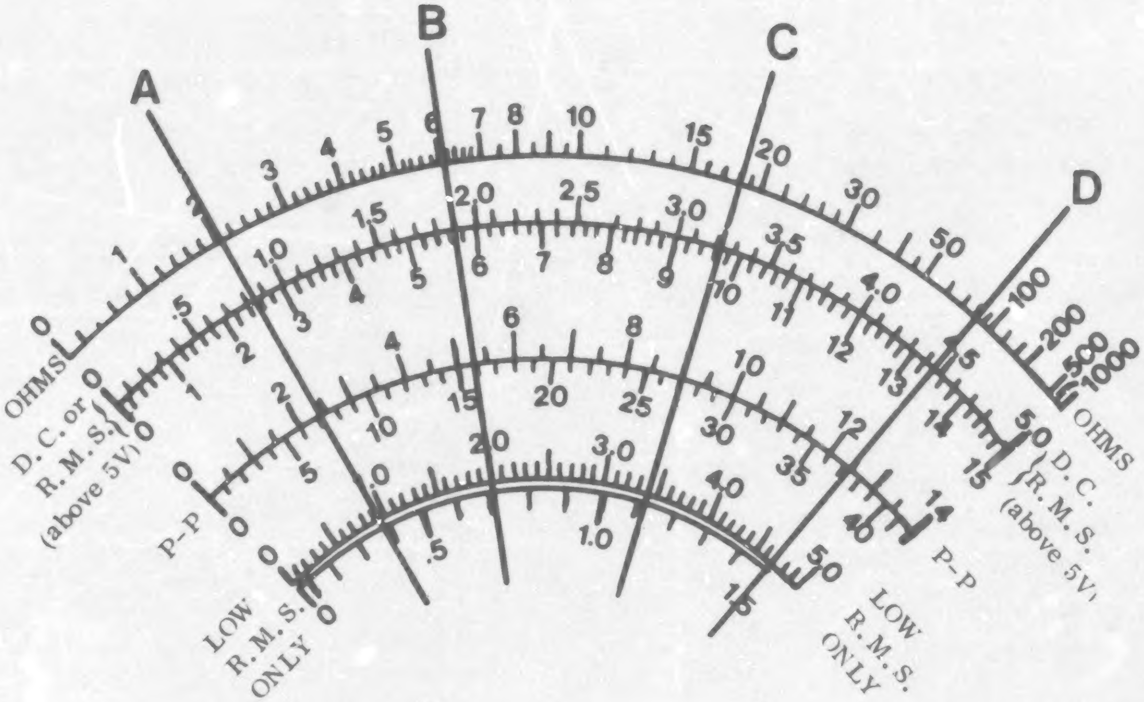
____________________ 6. For your safety, always connect meters to circuits with the power turned ______ whenever possible.

____________________ 7. Care must be taken not to _______ more than one point in a circuit with a meter probe.

____________________ 8. The ______ must be set on an ohmmeter before making any measurements to insure a more accurate reading.

____________________ 9. Never connect a/an _______ meter to a circuit having any voltage.

____________________ 10. An ammeter can be ruined instantly if connected across a/an ______.


A
B
C
D
OHMS
0
1
2
3
4
5
6
7
8
10
15
20
30
50
100
200
500
1000
OHMS
D. C. or R. M. S. (above 5V)
D. C. R. M. S. (above 5V)
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
2
4
6
8
10
12
14
P-P
0
5
10
15
20
25
30
35
40
P-P
0
.5
1.0
1.5
.5
1.0
2.0
3.0
4.0
5.0
LOW R. M. S. ONLY
LOW R. M. S. ONLY

Directions: Complete the chart using the meter scale and pointers in figure 1. Be sure to check your answers.

	Function	Range	Pointer	Reading
11.	ACV	1.5	A	
12.	DCV	500	B	
13.	Ohms	x10K	C	
14.	ACV	50	D	
15.	DCV	15	A	
16.	Ohms	x10	B	
17.	ACV	150	C	
18.	DCV	50	D	
19.	Ohms	x1K	A	
20.	ACV	5	B	
21.	DCV	15	C	
22.	Ohms	x100K	D	
23.	ACV	1500	A	
24.	DCV	5	B	
25.	Ohms	1M	C	

TEST

Name ______________________ Date ______________________

DIRECTIONS: Laid out on the lab bench are fourteen hand tools numbered 1 to 14. When it is your turn, identify each tool in order by its proper name. Be sure to check your answers for correct spelling.

1. ______________________ 8. ______________________
2. ______________________ 9. ______________________
3. ______________________ 10. ______________________
4. ______________________ 11. ______________________
5. ______________________ 12. ______________________
6. ______________________ 13. ______________________
7. ______________________ 14. ______________________

Directions: List the six safety rules for hand tools.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

TEST

II-D-1(T)

Name ______________________ Date ______________________

DIRECTIONS: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Check your answers to be sure they are correct.

________________ 1. Always wear ____ when soldering or cutting wire.

________________ 2. The process of ____ is used in electronics to make reliable component connections.

________________ 3. The solder alloy most commonly used in electronics is _____.

________________ 4. The ____ alloy ratio determines the melting temperature of solder.

________________ 5. Only ____ solder flux should be used for electronics and electrical work.

________________ 6. The chemical cleaning of oxide from metal parts is done using solder ____.

________________ 7. The bond that takes place between solder and other metals is called _____.

________________ 8. Most soldering of electronic components is done with a ____ style soldering iron.

________________ 9. A soldering iron with a ____ watt rating should be used to prevent component damage.

________________ 10. To make consistently good connections, you should ____ your soldering iron tip each time you pick it up.

________________ 11. Good solder connections should look smooth and ____.

________________ 12. Most bad solder connections are caused by excessive solder or not enough _____.

________________ 13. Two common methods of desoldering are the flux coated ____ and the vacuum bulb.

DIRECTIONS: List the seven steps required to safely make a good solder connection in the following spaces.

14. ____

15. ____

16. ____

17. ____

18. ____

19. ____

20. ____

TEST

Name ______________________________ Date ________________________

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

__________________ 1. The ____ contains one or more protons and usually one or more neutrons as well.

__________________ 2. A/an ____ is a negatively charged particle that forms the outside part of an atom.

__________________ 3. An atom with negative charge is called a negative ____.

__________________ 4. The flow of electrons is called an electric ____.

__________________ 5. An electron that can move from one atom to another is called a/an ____ electron .

__________________ 6. A material that has ____ free electrons is called a conductor.

__________________ 7. A material that has ____ free electrons is called an insulator.

__________________ 8. The usual cause of static electricity is ____.

__________________ 9. When ____ charges are brought near each other, they tend to repel each other.

__________________ 10. The pressure that causes current flow is called voltage, difference of potential or ____ force.

__________________ 11. A negative one ____ charge can be obtained by adding 6.25×10^{18} electrons to an object.

__________________ 12. The direction of current flow in a circuit is from the more _____ terminal of the voltage source.

__________________ 13. For ____, eye protection should be worn when handling storage batteries.

__________________ 14. A dry cell produces approximately ____ volts.

Directions: Match the terms in column A with the terms in column B. Write the letter representing the correct answer in the space provided. Be sure to check your answers.

	Column A	Column B
______	15. Difference of Potential	A. Friction
______	16. Electron Flow	B. Heat
______	17. Static Electricity	C. Mechanical
______	18. Coulombs per Second	D. Q
______	19. Thermocouple	E. Chemical
______	20. Voltaic Cell	F. EMF
______	21. Piezoelectric	G. Negative
______	22. Generator	H. Current
______	23. Charge	I. Nucleus
______	24. Electrons	J. Quartz
______	25. Protons	K. Ampere

TEST III-B-1(T)

Name ______________________ Date ____________________

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

______________ 1. It takes electrical ____ to get current to flow through a resistance.

______________ 2. Resistors dissipate energy in the form of ____.

______________ 3. The ability of a material to conduct electricity is called ____.

______________ 4. Resistance is the ability of a material to ____ the flow of electric current.

______________ 5. Heating elements are constructed using ____ wire because of its high resistance.

______________ 6. A variable resistor called a ____ is used to vary voltage in a circuit.

______________ 7. The larger the gage number of a wire, the ____ resistance it has for a given length.

______________ 8. Metal film resistors are made to dissipate greater than 3 watts of power. (true or false)

______________ 9. The fifth color band on a resistor indicates the ____ of the resistor.

______________ 10. Care must be taken when measuring resistance to be sure there is no ____ present in the circuit.

______________ 11. The physical size of a resistor is an indication of its power rating. (true or false)

______________ 12. As electrons move through a material, heat is produced by ____ as they rub against each other.

______________ 13. The smaller the American Wire Gage number, the ____ the resistance.

______________ 14. A/an ____ taper control changes proportionally with the shaft rotation.

__________________ 15. Be sure to ____ an ohmmeter each time it is used to insure more accurate readings.

Directions: Complete the following table for the ten resistors on the resistor test board. The first five (R1 to R5) are color coded. Record their marked values and tolerance. The second five (R6 to R10) are not color coded. Measure and record their values.

R1________________ 16.

R2________________ 17.

R3________________ 18.

R4________________ 19.

R5________________ 20.

R6________________ 21.

R7________________ 22.

R8________________ 23.

R9________________ 24.

R10_______________ 25.

TEST

III-C-1(T)

Name ______________________________ Date ________________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

__________ 1. If the current in a circuit remains constant and the resistance increases, the voltage will ____.
A. increase B. decrease C. remain the same

__________ 2. If the resistance in a circuit remains constant and the current increases, the voltage will ____.
A. increase B. decrease C. remain the same

__________ 3. Power is the ____.
A. same as electromotive force
B. number of electrons forced through a resistance
C. same as conductance
D. rate of producing or using energy

__________ 4. Calculate the resistance of a 300 watt light bulb connected across a 120 Volt power line.
A. 24 Ohms B. 36 KOhms C. 48 Ohms D. 6.9 Ohms

__________ 5. If a 12 V battery is across a resistance of 6 KOhms, the current flow through the resistance is ____.
A. 0.2 mA B. 2 mA C. 20 mA D. 2 A

__________ 6. A potential difference of ____ applied across a 1 MOhm resistor will produce a current of 1 mA.
A. 1 μV B. 1 mV C. 1 KV D. 1,000,000 V

__________ 7. A circuit allows 1 mA of current to flow with 1 V applied. The conductance of the circuit is ____.
A. 0.001 Ohm B. 0.001 μOhm C. 1,000 μMho D. 1 Mho

__________ 8. A source of 5 V applied across a resistance of 1,000 Ohms produces a current of ____.
A. 5 μA B. 5 mA C. 50 mA D. 5 A

__________ 9. If a current of 200 μA is produced when a source of 30 V is applied, the resistance of the circuit is ____.
A. 150 Ohms B. 6 KOhms C. 6 MOhms D. 150 KOhms

____________ 10. A current of ____ will flow in a circuit which has a resistance of 2,500 Ohms connected to a 50 Volt source.

A. 125 A B. 0.02 A C. 200 mA D. 2 mA

Directions: Solve the following circuit problems using Ohm's Law and the power formulas. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers.

____________ 11. What is the power dissipated by a 50 Ohm lamp that has 150 mA flowing through it?

____________ 12. A computer uses 175 W from the 120 V power source. The computer draws ____ of current.

____________ 13. What is the current through a 500 W electric toaster if the resistance is 50 Ohms?

____________ 14. If a current of 2 mA passes through a 5 KOhm resistor, the source voltage is ____.

____________ 15. If the voltage in a circuit is 20 V and the resistance is 4 Kohms, the power will be ____.

____________ 16. Calculate the resistance which has 120 V applied across it and is dissipating 800 Watts.

____________ 17. If 4.5 mA of current flows through a 10 Ohm device, the voltage across it equals ____.

____________ 18. If the voltage in a circuit is 10 V and the power is 2 mW, the current is ____.

____________ 19. In a circuit where the source voltage is 20 V and the total circuit current is 200 mA, how much power is being dissipated?

____________ 20. If the voltage in a circuit is 100 Volts and the current is 0.2 mA, the power dissipated is ____.

TEST IV-A-1(T)

Name ____________________ Date ____________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

________ 1. Two resistors connected in series must have
A. the same resistance value.
B. the same voltage drop across them.
C. different resistance values.
D. the same current flowing through them.

________ 2. With two equal resistances in series across a 90 Volt battery, each resistance will have a voltage of _____.
A. 30 V B. 45 V C. 90 V D. 180 V

________ 3. In a series circuit, the current through R_1 is 1A. The current through R_2 must be ____.
A. 0.333 A B. 500 mA C. 1.00 A D. 2.00 A

________ 4. If the filaments of several lamps are to be connected in series, they must have the same _____ rating.
A. resistance B. voltage C. current D. power

Directions: List the four characteristics for series circuit analysis.

____________________ 5. Total Voltage

____________________ 6. Total Current

____________________ 7. Total Resistance

____________________ 8. Total Power

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

__________ 9. Ohm's Law and _____ Law can be very useful in solving series circuits.

__________ 10. When a resistor in a series circuit becomes ____, the current is zero in all resistances.

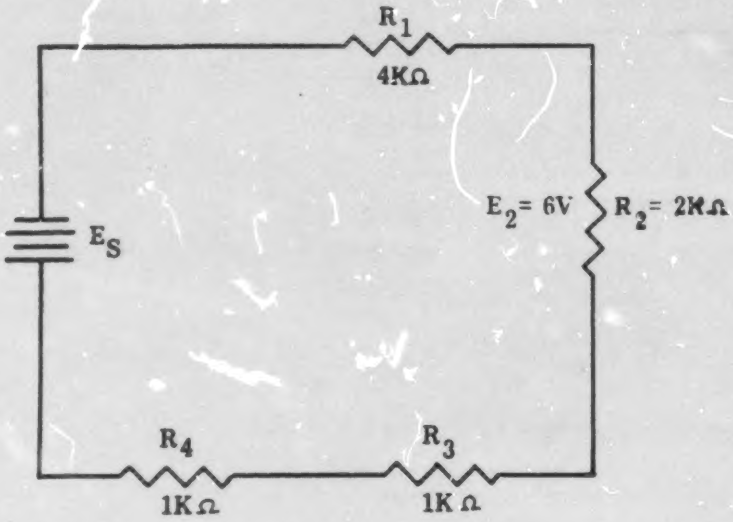
__________ 11. The total resistance in a series circuit will always be ____ than the largest resistance.

____________ 12. If a resistor in a series circuit becomes shorted, the total current will ____.

____________ 13. The sum of all the voltages around a series circuit will equal zero. (True or False)

Directions: Use the circuit below to solve for the indicated unknown values. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers.

14. I_T = ____________
15. E_S = ____________
16. E_1 = ____________
17. E_2 = ____________
18. R_T = ____________
19. P_4 = ____________
20. P_3 = ____________
21. P_2 = ____________
22. I_3 = ____________
23. P_1 = ____________
24. P_T = ____________
25. E_4 = ____________



TEST IV-B-1(T)

Name ______________________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

__________ 1. Two resistors connected in parallel must have
- A. the same resistance value.
- B. the same voltage drop across them.
- C. different resistance values.
- D. the same current flowing through them.

__________ 2. If 100 V is across ten 50 Ohm resistances connected in parallel, the current through each resistance is ____.
A. 2.00 A   B. 10.0 A   C. 20.0 A   D. 100 A

__________ 3. When two parallel resistances are dissipating 10 Watts each, the total power from the source is ____.
A. 5 Watts   B. 10 Watts   C. 20 Watts   D. 100 Watts

__________ 4. If a parallel circuit containing resistances of 12, 15 and 20 Ohm is connected across as 120 V source, the total current is ___.
A. 240 mA   B. 2.40 mA   C. 0.240 A   D. 2.40 A

Directions: List the four characteristics for parallel circuit analysis.

______________________________ 5. Total Voltage

______________________________ 6. Total Current

______________________________ 7. Total Resistance

______________________________ 8. Total Power

Directions: Read each statement carefully. Select the word or words which best completes each statement and place it in the space provided. Be sure to check your answers.

__________ 9. Ohm's Law and ___ Current Law can be very useful in solving parallel circuit.

__________ 10. When a parallel circuit branch opens, the current will be normal in the other branches. (True or False)

__________ 11. If a 10 Ohm and a 15 Ohm resistor are connected in a parallel circuit having a total current of 2.00 A, the applied voltage is ____.

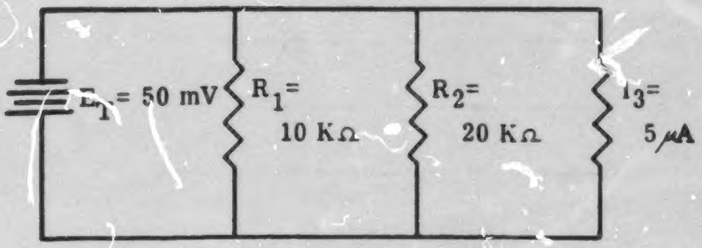
__________ 12. The ____ is the same across each branch of a parallel circuit.

__________ 13. In a parallel circuit, the current is the same in all branches. (True or False)

__________ 14. If a branch of a parallel circuit becomes shorted, the rest of the circuit will continue to function normally. (True or False)

Directions: Use the circuit below to solve for the indicated unknown values. Round off your answers to three significant figures and write them in the space provided using the proper metric prefix. Be sure to check your answers.

15. I_T = ____________________
16. R_T = ____________________
17. P_T = ____________________
18. E_1 = ____________________
19. E_3 = ____________________
20. I_1 = ____________________
21. I_2 = ____________________
22. R_3 = ____________________
23. P_1 = ____________________
24. P_2 = ____________________
25. P_3 = ____________________



TEST IV-C-1(T)

Name ______________________ Date ____________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

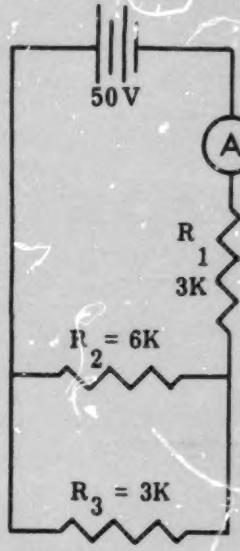


figure 1

_______ 1. The total resistance of the circuit in figure 1 is ____.
A. 3.00 K Ohms C. 5.00 K Ohms
B. 4.00 K Ohms D. 6.00 K Ohms

_______ 2. The total current in the circuit in figure 1 is ____.
A. 0.100 A C. 1.00 mA
B. 0.0100 A D. 0.100 mA

_______ 3. The voltage drop across R_1 in figure 1 is ____.
A. 10.0 V C. 30.0 V
B. 20.0 V D. 40.0 V

_______ 4. The current through R_3 in figure 1 is ____.
A. 0.00667 A C. 6.67 A
B. 66.7 mA D. 10.0 mA

_______ 5. The total power dissipated by the circuit in figure 1 is ____.
A. 5.00 W C. 50.0 mW
B. 0.500 W D. 5.00 mW

R1=300K
R2=1M
R3=1M
R4=300K
R5=600K

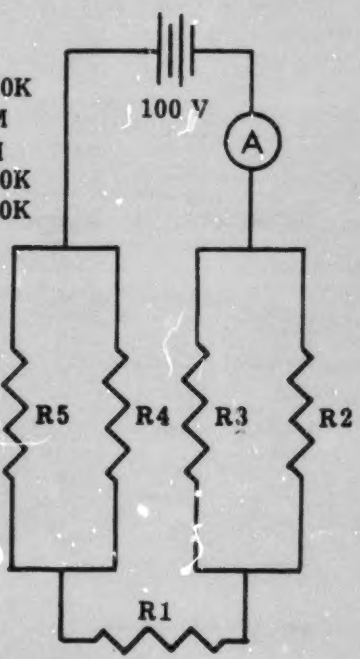


figure 2

_______ 6. The total resistance of the circuit in figure 2 is ____.
A. 1.00 M Ohms C. 600 Ohms
B. 900 K Ohms D. 500 Ohms

_______ 7. The total current in the circuit in figure 2 is ____.
A. 0.010 mA C. 1.00 A
B. 0.100 mA D. 10.0 A

_______ 8. The voltage across R_3 in the circuit in figure 2 is ____.
A. 30.0 V C. 60.0 V
B. 50.0 V D. 75.0 V

__________ 9. The voltage drop across R_5 in the circuit in figure 2 is ____.

A. 20.0 V B. 30.0 V C. 50.0 V D. 60.0 V

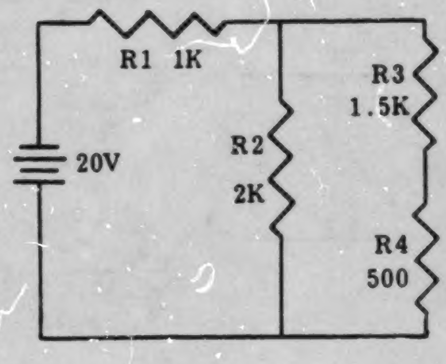
__________ 10. The power dissipated by R_1 in the circuit in figure 2 is ____.

A. 3.00 W B. 300 mW C. 30.0 mW D. 3.00 mW

__________ 11. The total current in the circuit in figure 3 is ____.

A. 1.00 mA C. 1.00 A
B. 10.0 mA D. 10.0 A

figure 3



__________ 12. The total resistance in the circuit in figure 3 is ____.

A. 5.00 K Ohms C. 3.00 K Ohms
B. 4.00 K Ohms D. 2.00 K Ohms

__________ 13. The voltage drop across R_2 in the circuit in figure 3 is ____.

A. 5.00 V C. 15.0 V
B. 10.0 V D. 20.0 V

__________ 14. The voltage drop across R_1 in the circuit in figure 3 is ____.

A. 5.00 V B. 10.0 V C. 15.0 V D. 20.0 V

__________ 15. The total power dissipated by the circuit in figure 3 is ____.

A. 2.00 W B. 0.200 W C. 20.0 mW D. 0.200 mW

Directions: Design a voltage divided circuit to provide 9 Volts at 50 mA from a 12 Volt power supply. Write the values indicated in the spaces provided. Be sure to check your answers.

__________ 16. Total supply current.

__________ 17. Bleeder current.

__________ 18. Bleeder resistor valve.

__________ 19. Dropping resistor valve.

__________ 20. Total circuit power with load.

TEST

IV-D-1(T)

Name ______________________________ Date ______________________________

Directions: Read each statement carefully. Answer the following questions and solve the problems carefully. Write your answers in the space provided. Use four significant figures and the proper metric prefix for calculated answers. Be sure to check your answers.

______________ 1. The most commonly used analog meter movement is the ____ movement.

______________ 2. The ____ of a meter movement can be expressed as the amount of current required for full-scale current.

______________ 3. The range of an ammeter can be extended by using a ____ resistor.

______________ 4. A/an ____ resistor is used to expand the range of a voltmeter.

______________ 5. Resistors used to expand the range of ____ meters typically have large resistance values.

______________ 6. The ____ indicates resistance by measuring the current flowing through a series circuit.

______________ 7. If an ohmmeter cannot be zero adjusted, the ____ should be replaced.

______________ 8. For safety reasons, an ohmmeter must never be used to measure resistance in a/an ____ circuit.

______________ 9. A/an ____ is a sensitive current measuring device that will measure current in either direction.

______________ 10. A bridge is ____ when there is zero current flowing through the measuring device.

______________ 11. Calculate the shunt required to convert a 1 mA, 100 Ohm meter to read 100 mA full scale.

______________ 12. A 50 μA meter movement has an internal resistance of 1,000 Ohms. What shunt value is needed for a current range of 10 mA?

______________ 13. For a 1.00 Volt range, a 50 μA meter movement with an internal resistance of 2,000 Ohms requires a multiplier resistance of ____.

__________ **14. With a 50 Ohm, 1 mA meter movement, calculate the multiplier resistance needed for a range of 30.0 V.**

__________ **15. The sensitivity of a meter movement can be changed using resistors. (True/False)**

TEST V-A-1(T)

Name ______________________________ Date ______________________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Be sure to check your answers.

____________ 1. The lines of force of a magnetic field are called magnetic ____.

____________ 2. Magnetic flux exits a magnet from the ____ pole of a magnet.

____________ 3. Magnetism is an invisible force ____ which exists around a magnet.

____________ 4. The ____ rule is used to determine the direction of flux around a conductor carrying current.

____________ 5. A material containing ____ is called a ferromagnetic material.

____________ 6. The ____ within a permanent magnet will remain aligned after removal from the magnetizing force.

____________ 7. The effort exerted in creating a magnetic field is called ____ force.

____________ 8. When a core material is ____, increasing the magnetomotive force will not increase the flux.

____________ 9. The flux that remains in a temporary magnet when the magnetizing field is removed is called ____ magnetism.

____________ 10. The opposition within a material to magnetic flux is ____.

____________ 11. The ability of a material to retain magnetism is called ____.

____________ 12. The ease with which magnetic flux will pass through a material is ____.

____________ 13. Ampere-turns is the basic unit of magnetomotive ____

____________ 14. The end of the compass needle pointing to the north geographic pole is the ____ pole of the magnetic needle.

____________ 15. Materials with low reluctance are called magnetic ____.

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

__________ 16. Magnetized materials have orderly arranged domains.

__________ 17. Permanent magnet materials have very little residual magnetism.

__________ 18. Permeability refers to the ability of a material to carry magnetic flux.

__________ 19. Magnetic flux is assumed to leave a north pole and enter a south pole.

__________ 20. Magnetic materials can be magnetized by putting them in the fields of magnets.

TEST V-B-1(T)

Name ______________________________ Date ______________________________

Directions: Read each statement carefully. Write the word or words which best completes the statement in the blank on the left. Be sure to check your answers.

____________ 1. The most common method of producing electricity is by rotating a ____ through a magnetic field.

____________ 2. One of the factors that controls generator output is speed of coil ____.

____________ 3. Graphite is used to make generator _____.

____________ 4. In comparing AC and DC generators, slip rings do the same job as ____.

____________ 5. Voltage output can be increased by adding more loops to the ___.

____________ 6. Slip rings are used on ____ generators.

____________ 7. Generators may be either field coil or ____ magnet.

____________ 8. A plunger is moved in a ____ by an electromagnetic field.

____________ 9. Repulsion is caused by ___ changes in permanent magnet motors.

____________ 10. Generator action can be described as an electric motor in ____.

____________ 11. In series DC motors the coils are wired ____.

____________ 12. Commutators are found in ____ generators.

____________ 13. Torque can be described as ____ or ____ force.

____________ 14. High voltage current can be controlled safely and economically with a ____ circuit.

____________ 15. Series DC motors have one path for the ____.

Directions: Read each statement carefully. Determine if the statement is true or false. Write a T or F in the space provided to indicate your answer.

__________ 16. Magnetic reed switches are usually the DPDT type.

__________ 17. Its armature will still turn in the same direction if a universal motor is changed from DC to AC.

__________ 18. Phase splitting, repulsion, and pole shading are used to start induction motors.

__________ 19. In series DC motors, counter emf increases with speed.

__________ 20. Field and armature coils are connected in parallel in shunt DC motors.

TEST

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

______ 1. A sine wave having a peak value of 25.5 V will have a peak-to-peak value of _____.
A. 12.75 V B. 25.5 V C. 38.25 V D. 51.0 V

______ 2. A sine wave having a peak value of 50 V will have an RMS value of _____.
A. 50 V B. 35.4 V C. 31.8 V D. 25 V

______ 3. A sine wave having a peak value of 80.5 V will have an effective value of _____.
A. 56.9 V B. 161 V C. 80.5 V D. 51.3 V

______ 4. A sine wave having a period of 1/1000 second will have a frequency of _____.
A. 2,000 Hz B. 1,000 Hz C. 500 Hz D. 250 Hz

______ 5. A sine wave taking 5 μseconds for a complete cycle will have a frequency of _____.
A. 5 K Hz B. 200 Hz C. 200 K Hz D. 250 K Hz

______ 6. If the frequency of a sine wave is 550 Hz, the period of the wave is _____.
A. 1 m Sec B. 1.8 m Sec C. 2 m Sec D. 2.8 m Sec

______ 7. The DC voltage necessary to produce the same amount of power as a 10 V peak sine wave is _____.
A. 20 V B. 10 V C. 7.07 V D. 6.37 V

______ 8. In one cycle of alternating current there is/are ____ alternations.
A. one B. two C. three D. four

______ 9. A term that can be used to identify the effective value of an AC is _____.
A. peak B. peak-to-peak C. average D. RMS

______ 10. The value which represents the difference between the maximum positive and maximum negative values of an AC sine wave is called the ____ value.
A. peak B. peak-to-peak C. average D. RMS

_______ 11. The wavelength of an electromagnetic wave is determined by its _____.
A. velocity and frequency
B. velocity per second
C. frequency and time
D. magnitude

_______ 12. The formula for finding the wavelength of an AC wave is wavelength = _____.
A. V/t B. Vt C. f/V D. V/f

_______ 13. Electromagnetic waves travel at approximately _____.
A. 186,000 meters per second
B. 186,000 miles per hour
C. 300,000,000 meters per second
D. 300,000,000 meters per hour

_______ 14. For most general purpose work the oscilloscope shows how _____ changes with changes in time.
A. voltage B. current C. frequency D. period

_______ 15. Except for special purpose oscilloscopes, the displayed waveform must be a _____ wave.
A. sine B. cyclical C. square D. graph

_______ 16. The electron beam in a CRT is moved by electrostatic forces applied to the beam by the ____.
A. grids B. cathode C. deflection plates

_______ 17. For most applications, the horizontal deflection amplifier is used to amplify the _____ signal.
A. sweep B. input C. trigger D. blanking

_______ 18. The calibrated vertical section of an oscilloscope lets you make _____ measurements.
A. time B. period C. frequency D. voltage

_______ 19. A calibrated horizontal section of an oscilloscope allows accurate _____ measurements.
A. time B. current C. frequency D. voltage

_______ 20. The trace-retrace of the electron beam is controlled by a ____ wave in most oscilloscopes.
A. square B. sine C. sawtooth D. distorted

Directions: Match the items in the left column with the items in the right column. Place the letter representing the correct match in the space provided. Be sure to check your answers.

________ 21. Intensity control

________ 22. Horizontal control

________ 23. Vertical control

________ 24. Focus control

________ 25. Sawtooth wave

A. Input wave

B. Volts/cm

C. Clarity of display

D. Time/cm

E. Brightness of display

F. Sweep wave

TEST

VI-B-1(T)

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

________ 1. Which of the following will NOT increase the inductance of a coil?
A. Change the core to soft iron.
B. Add more turns on the coil.
C. Increase the core permeability.
D. Increase the amount of current.

________ 2. An inductor stores energy in a/an _____.
A. magnetic field C. induced voltage
B. electrostatic field D. ion

________ 3. Induction occurs when the magnetic field is _____.
A. minimum B. maximum C. changing D. at rest

________ 4. What is the inductance of a coil that has 100 Volts induced when the current changes at the rate of 25 A in two seconds?
A. 0.4 H B. 4.0 H C. 8.0 H D. 0.8 H

________ 5. A 10 H and a 20 H coil are connected in series aiding with a mutual inductance of 1 H. What is the total inductance of the coils?
A. 64 H B. 32 H C. 30 H D. 15 H

________ 6. If a coil induces a voltage in another coil, _____ inductance exists.
A. mutual B. self C. aiding D. opposing

________ 7. If a circuit has only inductive reactance,
A. there would be no opposition to current.
B. there would be no current flow.
C. current would lead the voltage by 90°.
D. current would lag the voltage by 90°.

________ 8. If the frequency of the current is increased through a coil, the current would _____.
A. decrease C. change to DC
B. increase D. remain the same

________ 9. What is the voltage-current relationship in an inductive circuit?
A. voltage lags current.
B. current lags voltage.
C. voltage and current are in-phase.
D. voltage leads the current by 180°.

__________ 10. The symbol X_L represents _____.

A. inductance
C. unknown inductance
B. inductive reactance
D. coil resistance

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Answers to calculations should have three significant figures and written using the proper metric prefix. Be sure to check your answers.

__________ 11. There must be _____ between a conductor and a magnetic field for induction to take place.

__________ 12. Lenz's Law states that any _____ generated by induction must oppose the motion that produced it.

__________ 13. A low value of k indicates _____ coupling.

__________ 14. What is the voltage induced across an 8 H coil by a current changing at the rate of 16 A per second?

__________ 15. If two 400 mH coils have a k of 0.2, then the L_M will be _____.

__________ 16. Any undesired inductance is _____ inductance.

__________ 17. As the frequency of AC is decreased in a coil, the inductive reactance will _____.

__________ 18. The _____ in a transformer primary circuit will equal to the secondary circuit.

__________ 19. The _____ winding of a transformer is connected to the load circuit.

__________ 20. A 10 μH coil will have a reactance of 1 K Ohm at a frequency of _____.

__________ 21. A transformer is an application of the theory of _____.

__________ 22. Inductive reactance is the _____ by a coil to AC current flow.

__________ 23. A 10 mH and a 15 mH coil are connected in parallel without L_M, the total inductance is _____.

__________ 24. In a pure inductor, the voltage _____ the current by 90°.

__________ 25. What is the reactance of a coil with 7.5 V across it and 10 mA flowing through it?

TEST

VI-C-1(T)

Name ______________________ Date ______________________

Directions: Read each statement carefully. Each has four possible answers lettered A, B, C, and D. Write the letter representing the best answer in the space provided. Be sure to check your answers.

______ 1. The capacitance of a capacitor is inversely proportional to the
A. distance between the plates.
B. dielectric constant.
C. area of the plates.
D. length of the leads.

______ 2. The capacitance of a capacitor is directly proportional to the
A. distance between the plates.
B. dielectric resistance.
C. area of the plates.
D. length of the leads.

______ 3. The marked lead on a mylar capacitor should be connected to ____ side of the circuit.
A. positive
B. negative
C. low potential

______ 4. What will the capacitance of a 10 F capacitor be if the distance between the plates is doubled?
A. 10 μF
B. 5 μF
C. 20 μF
D. 0.2 μF

______ 5. Alternating current will cause a capacitor to
A. charge and discharge.
B. charge to the peak value.
C. charge to the RMS value.
D. not change.

______ 6. How much charge is stored in a 40 μF capacitor with 50 V across it?
A. 2,000 Coulombs
B. 2.00×10^3
C. 1.25 Coulombs
D. 0.800 μCoulomb

______ 7. As the frequency increases, the X_C will _____.
A. increase
B. stay the same
C. decrease
D. double

______ 8. The capacitive reactance of a 0.1 F capacitor at 1,000 Hz is ____.
A. 1 K Ohm
B. 1.6 K Ohm
C. 2 K Ohms
D. 3.2 K Ohms

______ 9. Two 1 K Ohm X_C value in series will have a total X_C of ____.
A. 500 Ohms
B. 1,000 Ohms
C. 1.414 K Ohms
D. 2,000 Ohms

______ 10. Two 1 K Ohm X_C value in parallel will have a total X_C of _____.
A. 500 Ohms
B. 707 Ohms
C. 1,000 Ohms
D. 2,000 Ohms

______ 11. The time constant of a 0.5 M Ohm resistor in series with a 2 μF capacitor across a 10 V battery is ____.
A. 1 μSecond
B. 1 Second
C. 2 Seconds
D. 0.5 Seconds

__________ 12. Five time constants for a 1 pF capacitor and 100 K Ohm resistor in series is _____.

A. 100 u Seconds
B. 100 p Seconds
C. 100 n Seconds
D. 100 Seconds

Directions: Read each statement carefully. Write the word or words which best completes the statement in the space provided. Answers to calculations should have three significant figures and written using the proper metric prefix. Be sure to check your answers.

______________ 13. Capacitive reactance acts as a/an _____ to AC current flow.

______________ 14. What size capacitance is needed for 100 Ohms of reactance at a frequency of 100 K Hz?

______________ 15. The insulating material used to separate the plates of a capacitor is called the _____.

______________ 16. Increasing the distance between the plates of a capacitor will ____ the capacitance.

______________ 17. Increasing the area of the plates of a capacitor will _____ the capacitance.

______________ 18. The maximum voltage that can be safely placed across a capacitor is called the _____.

______________ 19. Once a capacitor in a DC circuit is fully charged, the current will _____.

______________ 20. How much current will flow in a circuit if the reactance is 2 K Ohms and 10 V, 1,000 Hz is applied?

Directions: Read each statement carefully and determine if the statement is true or false. Place a T or F in the space provided to indicate your answer.

__________ 21. Two conductors separated by space form a capacitor.

__________ 22. A capacitor stores energy in the plates.

__________ 23. A Farad is the unit of measure for capacitance.

__________ 24. Capacitance is increased as the plate area increases.

__________ 25. Capacitance increases as the distance between the plate increases.